NUCLEIC ACID MOLECULES ENCODING A TRANSMEMBRANE SERINE PROTEASE 7, THE ENCODED POLYPEPTIDES AND METHODS BASED THEREON

RELATED APPLICATIONS

Benefit of priority under 35 U.S.C. §119(e) is claimed to U.S. provisional application Serial No. 60/275,592, filed March 13, 2001, to Edwin L. Madison and Edgar O. Ong, entitled "NUCLEIC ACID MOLECULES ENCODING A TRANSMEMBRANE SERINE PROTEASE, THE ENCODED PROTEINS AND METHODS BASED THEREON." The subject matter this application is incorporated in its entirety by reference thereto.

FIELD OF INVENTION

Nucleic acid molecules that encode proteases and portions thereof, particularly protease domains are provided. Also provided are prognostic, diagnostic and therapeutic methods using the proteases and domains thereof and the encoding nucleic acid molecules.

BACKGROUND OF THE INVENTION AND OBJECTS THEREOF

Cancer, which is a leading cause of death in the United States, is characterized by an increase in the number of abnormal neoplastic cells, which proliferate to form a tumor mass, the invasion of adjacent tissues by these neoplastic tumor cells, and the generation of malignant cells that metastasize via the blood or lymphatic system to regional lymph nodes and to distant sites. Among the hallmarks of cancer is a breakdown in the communication among tumor cells and their environment. Normal cells do not divide in the absence of stimulatory signals and cease dividing in the presence of inhibitory signals. Growth-stimulatory and growth-inhibitory signals, are routinely exchanged between cells within a tissue. In a cancerous, or neoplastic, state, a cell acquires the ability to "override" these signals and to proliferate under conditions in which normal cells do not grow.

In order to proliferate tumor cells acquire a number of distinct aberrant traits reflecting genetic alterations. The genomes of certain well-studied tumors carry several different independently altered genes,

including activated oncogenes and inactivated tumor suppressor genes. Each of these genetic changes appears to be responsible for imparting some of the traits that, in the aggregate, represent the full neoplastic phenotype.

A variety of biochemical factors have been associated with different phases of metastasis. Cell surface receptors for collagen, glycoproteins such as laminin, and proteoglycans, facilitate tumor cell attachment, an important step in invasion and metastases. Attachment triggers the release of degradative enzymes which facilitate the penetration of tumor cells through tissue barriers. Once the tumor cells have entered the target tissue, specific growth factors are required for further proliferation. Tumor invasion and progression involve a complex series of events, in which tumor cells detach from the primary tumor, break down the normal tissue surrounding it, and migrate into a blood or lymphatic vessel to be carried to a distant site. The breaking down of normal tissue barriers is accomplished by the elaboration of specific enzymes that degrade the proteins of the extracellular matrix that make up basement membranes and stromal components of tissues.

A class of extracellular matrix degrading enzymes have been implicated in tumor invasion. Among these are the matrix metalloproteinases (MMP). For example, the production of the matrix metalloproteinase stromelysin is associated with malignant tumors with metastatic potential (see, *e.g.*, McDonnell *et al.* (1990) *Smnrs. in Cancer Biology 1*:107-115; McDonnell *et al.* (1990) *Cancer and Metastasis Reviews 9*:309-319).

The capacity of cancer cells to metastasize and invade tissue is facilitated by degradation of the basement membrane. Several proteinase enzymes, including the MMPs, have been reported to facilitate the process of invasion of tumor cells. MMPs are reported to enhance degradation of the basement membrane, which thereby permits tumorous cells to invade tissues. For example, two major metalloproteinases

having molecular weights of about 70 kDa and 92 kDa appear to enhance ability of tumor cells to metastasize.

Type II Transmembrane Serine Proteases (TTSPs)

In addition to the MMPs, serine proteases have been implicated in neoplastic disease progression. Most serine proteases, which are either secreted enzymes or are sequestered in cytoplasmic storage organelles, have roles in blood coagulation, wound healing, digestion, immune responses and tumor invasion and metastasis. A class cell of surface proteins designated type II transmembrane serine proteases, which are membrane-anchored proteins with additional extracellular domains, has been identified. As cell surface proteins, they are positioned to play a role in intracellular signal transduction and in mediating cell surface proteolytic events.

Cell surface proteolysis is a mechanism for the generation of biologically active proteins that mediate a variety of cellular functions. These membrane-anchored proteins, include a disintegrin-like and metalloproteinase (ADAM) and membrane-type matrix metalloproteinase (MT-MMP). In mammals, at least 17 members of the TTSP family are known, including seven in humans (see, Hooper *et al.* (2001) *J. Biol. Chem. 276*:857-860). These include: corin (accession nos. AF133845 and AB013874; see, Yan *et al.* (1999) *J. Biol. Chem. 274*:14926-14938; Tomia *et al.* (1998) *J. Biochem. 124*:784-789; Uan *et al.* (2000) *Proc. Natl. Acad. Sci. U.S.A. 97*:8525-8529); enterpeptidase (also designated enterokinase; accession no. U09860 for the human protein; see, Kitamoto *et al.* (1995) *Biochem. 27*: 4562-4568; Yahagi *et al.* (1996) *Biochem. Biophys. Res. Commun. 219*:806-812; Kitamoto *et al.* (1994) *Proc. Natl. Acad. Sci. U.S.A. 91*:7588-7592; Matsushima *et al.* (1994) *J. Biol. Chem. 269*:19976-19982;); human airway trypsin-like protease (HAT; accession no. AB002134; see Yamaoka *et al. J. Biol. Chem. 273*:11894-11901); MTSP1 and matriptase (also called TADG-15; see SEQ ID Nos. 1 and 2; accession nos. AF133086/AF118224, AF04280022; Takeuchi *et*

al. (1999) *Proc. Natl. Acad. Sci. U.S.A. 96*:11054-1161; Lin *et al.* (1999) *J. Biol. Chem. 274:*18231-18236; Takeuchi *et al.* (2000) *J. Biol. Chem. 275*:26333-26342; and Kim *et al.* (1999) *Immunogenetics 49*:420-429); hepsin (see, accession nos. M18930, AF030065, X70900; Leytus *et al.* (1988) *Biochem. 27*: 11895-11901; Vu *et al.* (1997) *J. Biol. Chem. 272*:31315-31320; and Farley *et al.* (1993) *Biochem. Biophys. Acta 1173*:350-352; and see, U.S. Patent No. 5,972,616); TMPRS2 (see, Accession Nos. U75329 and AF113596; Paoloni-Giacobino *et al.* (1997) *Genomics 44*:309-320; and Jacquinet *et al.* (2000) *FEBS Lett. 468*: 93-100); and TMPRSS4 (see, Accession No. NM 016425; Wallrapp *et al.* (2000) *Cancer 60*:2602-2606).

Serine proteases, including transmembrane serine proteases, have been implicated in processes involved in neoplastic development and progression. While the precise role of these proteases has not been elaborated, serine proteases and inhibitors thereof are involved in the control of many intra- and extracellular physiological processes, including degradative actions in cancer cell invasion, metastatic spread, and neovascularization of tumors, that are involved in tumor progression. It is believed that proteases are involved in the degradation of extracellular matrix (ECM) and contribute to tissue remodeling, and are necessary for cancer invasion and metastasis. The activity and/or expression of some proteases have been shown to correlate with tumor progression and development.

For example, a membrane-type serine protease MTSP1 (also called matriptase; see SEQ ID Nos. 1 and 2 from U.S. Patent No. 5,972,616; and GenBank Accession No. AF118224; (1999) *J. Biol. Chem. 274*:18231-18236; U.S. Patent No. 5,792,616; see, also Takeuchi (1999) *Proc. Natl. Acad. Sci. U.S.A. 96*:11054-1161) that is expressed in epithelial cancer and normal tissue (Takeucuhi *et al.* (1999) *Proc. Natl. Acad. Sci. USA*, 96(20):11054-61) has been identified. Matriptase was originally identified in human breast cancer cells as a major gelatinase

(see, U.S. Patent No. 5,482,848), a type of matrix metalloprotease (MMP). It has been proposed that it plays a role in the metastasis of breast cancer. Matriptase also is expressed in a variety of epithelial tissues with high levels of activity and/or expression in the human gastrointestinal tract and the prostate. Other MTSPs, designated MTSP3, MTSP4 and MTSP6 and protease domains thereof, have been described in International PCT application No. PCT/US01/03471 and copending U.S. application Serial No. 09/776,191, filed February 2, 2001.

Prostate-specific antigen (PSA), a kallikrein-like serine protease, degrades extracellular matrix glycoproteins fibronectin and laminin, and, has been postulated to facilitate invasion by prostate cancer cells (Webber *et al.* (1995) *Clin. Cancer Res.*, 1(10):1089-94). Blocking PSA proteolytic activity with PSA-specific monoclonal antibodies results in a dose-dependent decrease *in vitro* in the invasion of the reconstituted basement membrane Matrigel by LNCaP human prostate carcinoma cells which secrete high levels of PSA.

Hepsin, a cell surface serine protease identified in hepatoma cells, is overexpressed in ovarian cancer (Tanimoto *et al.* (1997) *Cancer Res.*, 57(14):2884-7). The hepsin transcript appears to be abundant in carcinoma tissue and is almost never expressed in normal adult tissue, including normal ovary. It has been suggested that hepsin is frequently overexpressed in ovarian tumors and therefore can be a candidate protease in the invasive process and growth capacity of ovarian tumor cells.

A serine protease-like gene, designated normal epithelial cell-specific 1 (NES1) (Liu et al., *Cancer Res.*, 56(14):3371-9 (1996)) has been identified. Although expression of the NES1 mRNA is observed in all normal and immortalized nontumorigenic epithelial cell lines, the majority of human breast cancer cell lines show a drastic reduction or a complete lack of its expression. The structural similarity of NES1 to polypeptides known to regulate growth factor activity and a negative

correlation of NES1 expression with breast oncogenesis suggest a direct or indirect role for this protease-like gene product in the suppression of tumorigenesis.

Hence transmembrane serine proteases appear to be involved in the etiology and pathogenesis of tumors. There is a need to further elucidate their role in these processes and to identify additional transmembrane proteases. Therefore, it is an object herein to provide transmembrane serine protease (MTSP) proteins and nucleic acids encoding such MTSP proteases that are involved in the regulation of or participate in tumorigenesis and/or carcinogenesis. It is also an object herein to provide prognostic, diagnostic and therapeutic screening methods using such proteases and the nucleic acids encoding such proteases.

SUMMARY OF THE INVENTION

Provided herein are members of the Transmembrane Serine Protease family, particularly the Type II Transmembrane Serine Protease (TTSP) family (also referred to herein as MTSPs), and more particularly TTSP family members whose functional activity and/or expression differs in tumor cells from non-tumor cells in the same tissue. The MTSP provided herein is a heretofore unidentified MTSP family member, designated herein as MTSP7. The protease domain and full-length protein, including the zymogen and activated forms, and uses thereof are also provided. Proteins encoded by splice variants are also provided.

Assays for identifying effectors, such as small molecules and other conditions, that modulate the activation, expression or activity of MTSP7 are also provided herein. In exemplary assays, the affects of test compounds on the ability of a protease domain of MTSP7 to proteolytically cleave a known substrate, typically a fluorescently, chromogenically or otherwise detectably labeled substrate, are assessed. Agents, generally compounds, particularly small molecules, that modulate the activity of the protease domain are candidate compounds for modulating the activity of the MTSP7. The protease domains can also be

used to produce protease-specific antibodies. The protease domains provided herein include, but are not limited to, the single chain region having an N-terminus at the cleavage site for activation of the zymogen, through the C-terminus, or C-terminal truncated portions thereof that exhibit proteolytic activity as a single-chain polypeptide in *vitro* proteolysis assays, of any MTSP family member, including MTSP7, generally from a mammal, including human, that, for example, is expressed in tumor cells at different levels from non-tumor cells.

Nucleic acid molecules encoding the proteins and protease domains are also provided. The nucleic acid and amino acid sequences of an exemplary full length MTSP7 are set forth in SEQ ID Nos. 15 and 16, and the protease domain is set forth in SEQ ID No. 17 and 18. Nucleic acid molecules that encode a single-chain protease domain or catalytically active portion thereof and also those that encode the full-length MTSP7 are provided. Also provided are nucleic acid molecules that hybridize to such MTSP7-encoding nucleic acid along their full length and encode the protease domain or portion thereof are provided. Hybridization is generally effected under conditions of at least low, generally at least moderate, and often high stringency.

The isolated nucleic acid fragment is DNA, including genomic or cDNA, or is RNA, or can include other components, such as protein nucleic acid. The isolated nucleic acid may include additional components, such as heterologous or native promoters, and other transcriptional and translational regulatory sequences, these genes may be linked to other genes, such as reporter genes or other indicator genes or genes that encode indicators.

Also provided is an isolated nucleic acid molecule that includes the sequence of molecules that is complementary to the nucleotide sequence encoding MTSP7 or the portion thereof.

Also provided are fragments thereof or oligonucleotides that can be used as probes or primers and that contain at least about 10, 14, 16

nucleotides, generally less than 1000 or less than or equal to 100, set forth in SEQ ID No. 15 or 17 (or the complement thereof); or contain at least about 30 nucleotides (or the complement thereof) or contain oligonucleotides that hybridize along their full length (or at least about 70, 80 or 90% thereof) to any such fragments or oligonucleotides. The length of the fragments are a function of the purpose for which they are used and/or the complexity of the genome of interest. Generally probes and primers contain less than about 500, 150, 100 nucleotides.

Also provided are peptides that are encoded by such nucleic acid molecules. Included among those polypeptides are the MTSP7 protease domain or a polypeptide with amino acid changes such that the specificity and protease activity remains substantially unchanged. In particular, a substantially purified mammalian MTSP protein is provided that includes a serine protease catalytic domain and may additional include other domains. The MTSP7 can form homodimers and can also form heterodimers with some other protein, such as a membrane-bound protein. Also provided is a substantially purified protein including a sequence of amino acids that has at least 60%, 70%, 80%, 90% or about 95%, identity to the MTSP7 where the percentage identity is determined using standard algorithms and gap penalties that maximize the percentage identity. A human MTSP7 protein is exemplified, although other mammalian MTSP7 proteins are contemplated. Splice variants of the MTSP7, particularly those with a proteolytically active protease domain, are contemplated herein.

In other embodiments, substantially purified polypeptides that include a protease domain of a MTSP7 polypeptide or a catalytically active portion thereof, but that do not include the entire sequence of amino acids set forth in SEQ ID No. 18 are provided. Among these are polypeptides that include a sequence of amino acids that has at least 60%, 70%, 80%, 85%, 90%, 95% or 100% sequence identity to SEQ ID No. 16 or 18.

Muteins in which one or more of the Cys residues, particularly, a residue that is paired in the activated two form, but unpaired in the protease domain alone (*i.e.*, the Cys at residue position Cys313 (see SEQ ID Nos. 15-18) in the protease domain), is/are replaced with any amino acid, typically, although not necessarily, a conservative amino acid residue, such as Ser, are contemplated. Muteins of MTSP7, particularly those in which Cys residues, such as the Cys in the single chain protease domain, is replaced with another amino acid that does not eliminate the activity, are provided.

In certain embodiments, the MTSP7 polypeptide is detectable in a body fluid at a level that differs from its level in body fluids in a subject not having a tumor. In other embodiments, the polypeptide is present in a tumor; and a substrate or cofactor for the polypeptide is expressed at levels that differ from its level of expression in a non-tumor cell in the same type of tissue. In other embodiments, the substantially purified the level of expression and/or activity of the MTSP7 polypeptide in tumor cells differs from its level of expression and/or activity in non-tumor cells. In other embodiments, the MTSP7 is present in a tumor; and

a substrate or cofactor for the MTSP7 is expressed at levels that differ from its level of expression in a non-tumor cell in the same type of tissue.

In a specific embodiment, a nucleic acid that encodes a MTSP, designated MTSP7 is provided. In particular, the nucleic acid includes the sequence of nucleotides set forth in SEQ ID No. 15 or 17 or a portion there of that encodes a catalytically active polypeptide.

Also provided are nucleic acid molecules that hybridize under conditions of at least low stringency, generally moderate stringency, more typically high stringency to the SEQ ID No. 5 or degenerates thereof.

In one embodiment, the isolated nucleic acid fragment hybridizes to a nucleic acid molecule containing the nucleotide sequence set forth in SEQ ID No: 15 or 17 (or degenerates thereof) under high stringency

conditions, in one embodiments contains the sequence of nucleotides set forth in any of SEQ ID Nos. 15-18. A full-length MTSP7 is set forth in SEQ ID No. 18 and is encoded by SEQ ID No. 17 or degenerates thereof.

Also provided are muteins of the single chain protease domain of MTSP7 particularly muteins in which the Cys residue in the protease domain that is free (*i.e.*, does not form disulfide linkages with any other Cys residue in the protease domain) is substituted with another amino acid substitution, typically, although not necessarily, with a conservative amino acid substitution or a substitution that does not eliminate the activity, and muteins in which a glycosylation site(s) is eliminated. Muteins in which other conservative or non-conservative amino acid substitutions in which catalytic activity is retained are also contemplated (see, *e.g.*, Table 1, for exemplary amino acid substitutions). Hence, provided herein is a the family of transmembrane serine protease (MTSP) proteins designated MTSP7, and functional domains, especially protease (or catalytic) domains thereof, muteins and other derivatives and analogs thereof. Also provided herein are nucleic acids encoding the MTSP7s.

Additionally provided herein are antibodies that specifically bind to the MTSP7, cells, combinations, kits and articles of manufacture that contain the nucleic acid encoding the MTSP7 and/or the MTSP7. Further provided herein are prognostic, diagnostic, therapeutic screening methods using MTSP7 and the nucleic acids encoding MTSP7. Also provided are transgenic non-human animals bearing inactivated genes encoding the MTSP and bearing the genes encoding the MTSP7 under non-native promotor control are provided. Such animals are useful in animal models of tumor initiation, growth and/or progression models.

Of interest herein are MTSPs that are expressed or are activated in certain tumor or cancer cells such lung, prostate, colon and breast cancers. In particular, it is shown herein, that MTSP7 is expressed in lung carcinoma, leukemia and cervical carcinoma as well as in certain normal cells and tissues (see *e.g.*, EXAMPLES for tissue-specific

expression profile). MTSP7 also can be a marker for breast, prostate and colon cancer. The expression or activation of MTSP7 in a cell in a subject can be a marker for breast, prostate, lung, colon and other cancers.

MTSPs are of interest because they appear to be expressed and/or activated at different levels in tumor cells from normal cells, or have functional activity that is different in tumor cells from normal cells, such as by an alteration in a substrate therefor, or a cofactor. MTSP7 is of interest because it is expressed or is active in tumor cells. Hence the MTSP provided herein can serve as diagnostic markers for certain tumors. The level of activated MTSP7 can be diagnostic of cervical or lung cancer or leukemia.

Also provided herein are methods of modulating the activity of the MTSP7 and screening for compounds that modulate, including inhibit, antagonize, agonize or otherwise alter the activity of the MTSP7. Of particular interest is the extracellular domain of MTSP7 that includes the proteolytic (catalytic) portion of the protein.

MTSP7 proteins, including, but not limited including splice variants thereof, and nucleic acids encoding MTSPs, and domains, derivatives and analogs thereof are provided herein. Single chain protease domains that have an N-terminus generated by activation of the zymogen form of MTSP7 are also provided. The cleavage site for the protease domain is at amino acid I_{206} (R↓IVQG). The Cys residues at positions C_{186}-C_{313}, which links protease domain to another domain, C_{233}-C_{249}, C_{358}-C_{374} and C_{385}-C_{413} form disulfide bonds, so that upon cleavage the resulting polypeptide is a two chain molecule. Hence C_{313} is a free Cys in the protease domain, which can also be provided as a two chain molecule. It is shown herein, however, that the single chain form is proteolytically active.

Antibodies that specifically bind to the MTSP7, particularly the single chain protease domain, the zymogen and activated form, and cells, combinations, kits and articles of manufacture containing the MTSP7

proteins, domains thereof, or encoding nucleic acids are also provided herein. Transgenic non-human animals bearing inactivated genes encoding MTSP7 and bearing the genes encoding the MTSP7, particularly under a non-native promotor control or on an exogenous element, such as a plasmid or artificial chromosome, are additionally provided herein. Also provided are nucleic acid molecules encoding each of MTSP7 and domains thereof.

Also provided are plasmids containing any of the nucleic acid molecules provided herein. Cells containing the plasmids are also provided. Such cells include, but are not limited to, bacterial cells, yeast cells, fungal cells, plant cells, insect cells and animal cells.

Also provided is a method of producing MTSP7 by growing the above-described cells under conditions whereby the MTSP7 is expressed by the cells, and recovering the expressed MTSP7 protein. Methods for isolating nucleic acid encoding other MTSP7s are also provided.

Also provided are cells, generally eukaryotic cells, such as mammalian cells and yeast cells, in which the MTSP7 protein is expressed on the surface of the cells. Such cells are used in drug screening assays to identify compounds that modulate the activity of the MTSP7 protein. These assays including *in vitro* binding assays, and transcription based assays in which signal transduction mediated directly or indirectly, such as via activation of pro-growth factors, by the MTSP7 is assessed.

Further provided herein are prognostic, diagnostic and therapeutic screening methods using the MTSP7 and the nucleic acids encoding MTSP7. In particular, the prognostic, diagnostic and therapeutic screening methods are used for preventing, treating, or for finding agents useful in preventing or treating, tumors or cancers such as lung carcinoma, colon adenocarcinoma and ovarian carcinoma.

Also provided are methods for screening for compounds that modulate the activity of MTSP7. The compounds are identified by contacting them with the MTSP7 or protease domain thereof and a

substrate for the MTSP7. A change in the amount of substrate cleaved in the presence of the compounds compared to that in the absence of the compound indicates that the compound modulates the activity of the MTSP7. Such compounds are selected for further analyses or for use to modulate the activity of the MTSP7, such as inhibitors or agonists. The compounds can also be identified by contacting the substrates with a cell that expresses the MTSP7 or the extracellular domain or proteolytically active portion thereof.

Also provided herein are modulators of the activity of MTSP7, especially the modulators obtained according to the screening methods provide herein. Such modulators can have use in treating cancerous conditions, and other neoplastic conditions.

Pharmaceutical composition containing the protease domain and/or full-length or other domain of an MTSP7 protein are provided herein in a pharmaceutically acceptable carrier or excipient are provided herein.

Also provided are articles of manufacture that contain MTSP7 protein and protease domains of MTSP7 in single chain forms or activated forms. The articles contain a) packaging material; b) the polypeptide (or encoding nucleic acid), particularly the single chain protease domain thereof; and c) a label indicating that the article is for using ins assays for identifying modulators of the activities of an MTSP7 protein is provided herein.

Conjugates containing a) a MTSP7 protein or protease domain in single chain from; and b) a targeting agent linked to the MTSP directly or via a linker, wherein the agent facilitates: i) affinity isolation or purification of the conjugate; ii) attachment of the conjugate to a surface; iii) detection of the conjugate; or iv) targeted delivery to a selected tissue or cell, is provided herein. The conjugate can contain a plurality of agents linked thereto. The conjugate can be a chemical conjugate; and it can be a fusion protein.

In yet another embodiment, the targeting agent is a protein or peptide fragment. The protein or peptide fragment can include a protein binding sequence, a nucleic acid binding sequence, a lipid binding sequence, a polysaccharide binding sequence, or a metal binding sequence.

Methods of diagnosing a disease or disorder characterized by detecting an aberrant level of an MTSP7 in a subject is provided. The method can be practiced by measuring the level of the DNA, RNA, protein or functional activity of the MTSP7. An increase or decrease in the level of the DNA, RNA, protein or functional activity of the MTSP, relative to the level of the DNA, RNA, protein or functional activity found in an analogous sample not having the disease or disorder (or other suitable control) is indicative of the presence of the disease or disorder in the subject or other relative any other suitable control.

Combinations are provided herein. The combination can include: a) an inhibitor of the activity of an MTSP7; and b) an anti-cancer treatment or agent. The MTSP inhibitor and the anti-cancer agent can be formulated in a single pharmaceutical composition or each is formulated in a separate pharmaceutical composition. The MTSP7 inhibitor can be an antibody or a fragment or binding portion thereof made against the MTSP7, such as an antibody that specifically binds to the protease domain, an inhibitor of MTSP7 production, or an inhibitor of MTSP7 membrane-localization or an inhibitor of MTSP7 activation. Other MTSP7 inhibitors include, but are not limited to, an antisense nucleic acid or double-stranded RNA (dsRNA), such as RNAi, encoding the MTSP7, particularly a portion of the protease domain; a nucleic acid encoding at least a portion of a gene encoding the MTSP7 with a heterologous nucleotide sequence inserted therein such that the heterologous sequence inactivates the biological activity encoded MTSP7 or the gene encoding it. For example, the portion of the gene encoding the MTSP7 can flank the

heterologous sequence to promote homologous recombination with a genomic gene encoding the MTSP7.

Also, provided are methods for treating or preventing a tumor or cancer in a mammal by administering to a mammal an effective amount of an inhibitor of an MTSP7, whereby the tumor or cancer is treated or prevented. The MTSP7 inhibitor used in the treatment or for prophylaxis is administered with a pharmaceutically acceptable carrier or excipient. The mammal treated can be a human. The treatment or prevention method can additionally include administering an anti-cancer treatment or agent simultaneously with or subsequently or before administration of the MTSP7 inhibitor.

Also provided is a recombinant non-human animal in which an endogenous gene of an MTSP7 has been deleted or inactivated by homologous recombination or insertional mutagenesis of the animal or an ancestor thereof. A recombinant non-human animal is provided herein, where the gene of an MTSP7 is under control of a promoter that is not the native promoter of the gene or that is not the native promoter of the gene in the non-human animal or where the nucleic acid encoding the MTSP7 is heterologous to the non-human animal and the promoter is the native or a non-native promoter or the MTSP7 is on an extrachromosomal element, such as a plasmid or artificial chromosome.

Also provided are methods of treatments of tumors by administering a prodrug that is activated by MTSP7 that is expressed or active in tumor cells, particularly those in which its functional activity in tumor cells is greater than in non-tumor cells. The prodrug is administered and, upon administration, active MTSP7 expressed on cells cleaves the prodrug and releases active drug in the vicinity of these cells. The active anti-cancer drug accumulates in the vicinity of the tumor. This is

particularly useful in instances in which MTSP7 is expressed or active in greater quantity, higher level or predominantly in tumor cells compared to other cells.

Also provided are methods of identifying a compound that binds to the single-chain or two-chain form of MTSP7, by contacting a test compound with a both forms; determining to which form the compound binds; and if it binds to a form of MTSP7, further determining whether the compound has at least one of the following properties:

(i) inhibits activation of the single-chain zymogen form of MTSP7;

(ii) inhibits activity of the two-chain or single-chain form; and

(iii) inhibits dimerization of the protein.

The forms can be full length or the protease domain resulting from cleavage at the RI activation site.

Also provided are methods of diagnosing the presence of a pre-malignant lesion, a malignancy, or other pathologic condition in a subject, by obtaining a biological sample from the subject; exposing it to a detectable agent that binds to a two-chain or single-chain form of MTSP7, where the pathological condition is characterized by the presence or absence of the two-chain or single-chain form .

Methods of inhibiting tumor invasion or metastasis or treating a malignant or pre-malignant condition by administering an agent that inhibits activation of the zymogen form of MTSP7 or an activity of the activated form are provided. The conditions include, but are not limited to, a condition, such as a tumor, of the breast, cervix, prostate, lung, ovary or colon.

Antibodies that specifically bind to the two-chain or single-chain form of MTSP7 are provided. The antibodies include those that specifically bind to the two-chain or single-chain form of the protease domain and/or the full-length protein.

BRIEF DESCRIPTION OF THE DRAWING

The Figure illustrates the domain organization of the MTSP7. MTSP7 has a transmembrane domain, a SEA (sea urchin sperm protein-enterokinase-agrin) domain and a serine protease domain; sequences of the full length protein and encoding nucleic acid are also set forth in the figure (see also, SEQ ID Nos. 15-18).

DETAILED DESCRIPTION

A. DEFINITIONS

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as is commonly understood by one of ordinary skill in the art to which this invention belongs. All patents, applications, published applications and other publications and sequences from GenBank and other data bases referred to herein are incorporated by reference in their entirety.

As used herein, the abbreviations for any protective groups, amino acids and other compounds, are, unless indicated otherwise, in accord with their common usage, recognized abbreviations, or the IUPAC-IUB Commission on Biochemical Nomenclature (see, (1972) Biochem. 11:942-944).

As used herein, serine protease refers to a diverse family of proteases wherein a serine residue is involved in the hydrolysis of proteins or peptides. The serine residue can be part of the catalytic triad mechanism, which includes a serine, a histidine and an aspartic acid in the catalysis, or be part of the hydroxyl/ϵ-amine or hydroxyl/α-amine catalytic dyad mechanism, which involves a serine and a lysine in the catalysis.

As used herein, "transmembrane serine protease (MTSP)" refers to a family of transmembrane serine proteases that share common structural features as described herein (see, also Hooper *et al.* (2001) *J. Biol. Chem.276*:857-860). Thus, reference, for example, to "MTSP" encompasses all proteins encoded by the MTSP gene family, including but

are not limited to: MTSP1, MTSP3, MTSP4, MTSP6, MTSP7 or an equivalent molecule obtained from any other source or that has been prepared synthetically or that exhibits the same activity. Other MTSPs include, but are not limited to, corin, enterpeptidase, human airway trypsin-like protease (HAT), MTSP1, TMPRSS2, and TMPRSS4. The term also encompass MTSPs with amino acid substitutions that do not substantially alter activity of each member, and also encompasses splice variants thereof. Suitable conservative substitutions of amino acids are known to those of skill in this art and can be made generally without altering the enzymatic activity of the resulting molecule or without eliminating. Of particular interest are MTSPs of mammalian, including human, origin. Those of skill in this art recognize that, in general, single amino acid substitutions in non-essential regions of a polypeptide do not substantially alter biological activity (see, e.g., Watson et al. *Molecular Biology of the Gene*, 4th Edition, 1987, The Bejacmin/Cummings Pub. co., p.224).

MTSPs of interest include those that are activated and/or expressed in tumor cells at different levels, typically higher, from non-tumor cells; and those from cells in which substrates therefor differ in tumor cells from non-tumor cells or differ with respect to substrates, co-factors or receptors, or otherwise alter the specificity of the MTSP.

As used herein, a "protease domain of an MTSP" refers to the protease domain of MTSP that is located within the extracellular domain of a MTSP and exhibits proteolytic activity. It includes at least the smallest fragment thereof that acts catalytically as a single chain form. Hence it is at least the minimal portion of the extracellular domain that exhibits proteolytic activity as assessed by standard assays *in vitro* assays. Those of skill in this art recognize that such protease domain is the portion of the protease that is structurally equivalent to the trypsin or chymotrypsin fold. Contemplatd herein are such protease domains and catalytically active portions thereof.

The MTSP7 protein, with the protease domains indicated, is illustrated in Figure 1, Smaller portions thereof that retain protease activity are contemplated. The protease domains from MTSPs vary in size and constitution, including insertions and deletions in surface loops. They retain conserved structure, including at least one of the active site triad (see, *e.g.*, the catalytic triad of the MTSP in SEQ ID No. 16 is H_{248}, D_{293}, S_{389}), primary specificity pocket, oxyanion hole and/or other features of serine protease domains of proteases. Thus, for purposes herein, the protease domain is a portion of a MTSP, as defined herein, and is homologous to a domain of other MTSPs, such as corin, enterpeptidase, human airway trypsin-like protease (HAT), MTSP1, TMPRSS2, and TMPRSS4, which have been previously identified; it was not recognized, however, that an isolated single chain form of the protease domain could function proteolytically in *in vitro* assays. As with the larger class of enzymes of the chymotrypsin (S1) fold (see, *e.g.*, Internet accessible MEROPS data base), the MTSPs protease domains share a high degree of amino acid sequence identity. The His, Asp and Ser residues necessary for activity are present in conserved motifs. The activation site, which results in the N-terminus of second chain in the two chain forms is has a conserved motif and readily can be identified (see, *e.g.*, amino acids 2-6-208).

As used herein, the catalytically active domain of an MTSP refers to the protease domain. Reference to the protease domain of an MTSP includes the single and two-chain forms of any of these proteins. The zymogen form of each protein is single chain form, which can be converted to the active two chain form by cleavage. The protease domain can also be converted to a two chain form. By active form is meant a form active *in vivo* and/or *in vitro*.

Significantly, at least *in vitro*, the single chain forms of the MTSPs and the catalytic domains or proteolytically active portions thereof (typically C-terminal truncations) thereof exhibit protease activity. Hence

provided herein are isolated single chain forms of the protease domains of MTSPs and their use in *in vitro* drug screening assays for identification of agents that modulate the activity thereof.

As used herein an MTSP7, whenever referenced herein, includes at least one or all of or any combination of:

a polypeptide encoded by the sequence of nucleotides set forth in SEQ ID No. 15;

a polypeptide encoded by a sequence of nucleotides that hybridizes under conditions of low, moderate or high stringency to the sequence of nucleotides set forth in SEQ ID No. 15;

a polypeptide that comprises the sequence of amino acids set forth as amino acids 206-438 of SEQ ID No. 16;

a polypeptide that comprises a sequence of amino acids having at least about 60%, 70%, 80%, 85%, 90% or 95% sequence identity with the sequence of amino acids set forth in SEQ ID No. 16 or 17; and/or

a splice variant of the MTSP7 set forth in SEQ ID No. 15.

The MTSP7 can be from any animal, particularly a mammal, and includes but are not limited to, humans, rodents, fowl, ruminants and other animals. The full length zymogen or two-chain activated form is contemplated or any domain thereof, including the protease domain, which can be a two-chain activated form, or a single chain form.

As used herein, a human protein is one encoded by DNA present in the genome of a human, including all allelic variants and conservative variations as long as they are not variants found in other mammals.

As used herein, a "nucleic acid encoding a protease domain or catalytically active portion of a MTSP" shall be construed as referring to a nucleic acid encoding only the recited single chain protease domain or active portion thereof, and not the other contiguous portions of the MTSP as a continuous sequence.

As used herein, catalytic activity refers to the activity of the MTSP as a serine proteases. Function of the MTSP refers to its function in tumor biology, including promotion of or involvement in tumorigenesis, metastasis or carcinogenesis, and also roles in signal transduction.

As used herein, a zymogen is an inactive precursor of a proteolytic enzyme. Such precursors are generally larger, although not necessarily larger than the active form. With reference serine proteases zymogens are converted to active enzymes by specific cleavage, including catalytic and autocatalyic cleavage, or binding of an activating co-factor, which generates the mature active enzyme. A zymogen, thus, is an enzymatically inactive protein that is converted to a proteolytic enzyme by the action of an activator.

As used herein, "disease or disorder" refers to a pathological condition in an organism resulting from, *e.g.*, infection or genetic defect, and characterized by identifiable symptoms.

As used herein, neoplasm (neoplasia) refers to abnormal new growth, and thus means the same as *tumor*, which can be benign or malignant. Unlike *hyperplasia*, neoplastic proliferation persists even in the absence of the original stimulus.

As used herein, neoplastic disease refers to any disorder involving cancer, including tumor development, growth, metastasis and progression.

As used herein, cancer refers to a general term for diseases caused by any type of malignant tumor.

As used herein, malignant, as applies to tumors, refers to primary tumors that have the capacity of *metastasis* with loss of *growth control* and *positional control*.

As used herein, an anti-cancer agent (used interchangeable with "anti-tumor or anti-neoplastic agent") refers to any agents used in the anti-cancer treatment. These include any agents, when used alone or in combination with other compounds, that can alleviate, reduce, ameliorate,

prevent, or place or maintain in a state of remission of clinical symptoms or diagnostic markers associated with neoplastic disease, tumor and cancer, and can be used in methods, combinations and compositions provided herein. Non-limiting examples of anti-neoplastic agents include anti-angiogenic agents, alkylating agents, antimetabolite, certain natural products, platinum coordination complexes, anthracenediones, substituted ureas, methylhydrazine derivatives, adrenocortical suppressants, certain hormones, antagonists and anti-cancer polysaccharides.

As used herein, a splice variant refers to a variant produced by differential processing of a primary transcript of genomic DNA that results in more than one type of mRNA. Splice variants of MTSPs are provided herein.

As used herein, angiogenesis is intended to broadly encompass the totality of processes directly or indirectly involved in the establishment and maintenance of new vasculature (neovascularization), including, but not limited to, neovascularization associated with tumors.

As used herein, anti-angiogenic treatment or agent refers to any therapeutic regimen and compound, when used alone or in combination with other treatment or compounds, that can alleviate, reduce, ameliorate, prevent, or place or maintain in a state of remission of clinical symptoms or diagnostic markers associated with undesired and/or uncontrolled angiogenesis. Thus, for purposes herein an anti-angiogenic agent refers to an agent that inhibits the establishment or maintenance of vasculature. Such agents include, but are not limited to, anti-tumor agents, and agents for treatments of other disorders associated with undesirable angiogenesis, such as diabetic retinopathies, restenosis, hyperproliferative disorders and others.

As used herein, non-anti-angiogenic anti-tumor agents refer to anti-tumor agents that do not act primarily by inhibiting angiogenesis.

As used herein, pro-angiogenic agents are agents that promote the establishment or maintenance of the vasculature. Such agents include

agents for treating cardiovascular disorders, including heart attacks and strokes.

As used herein, undesired and/or uncontrolled angiogenesis refers to pathological angiogenesis wherein the influence of angiogenesis stimulators outweighs the influence of angiogenesis inhibitors. As used herein, deficient angiogenesis refers to pathological angiogenesis associated with disorders where there is a defect in normal angiogenesis resulting in aberrant angiogenesis or an absence or substantial reduction in angiogenesis.

As used herein, the protease domain of an MTSP protein refers to the protease domain of an MTSP that is located within or is the extracellular domain of an MTSP and exhibits proteolytic activity. Hence it is at least the minimal portion of the extracellular domain that exhibits proteolytic activity as assessed by standard assays *in vitro*. It refers, herein, to a single chain form heretofore thought to be inactive. Exemplary protease domains include at least a sufficient portion of sequences of amino acids set forth as amino acids 206-438 in SEQ ID No. 16 (encoded by nucleotides in SEQ ID No. 15; see also the Figure). Also contemplated are nucleic acid molecules that encode polypeptide that has proteolytic activity in an *in vitro* proteolysis assay and that have at least 60%, 70%, 80%, 85%, 90% or 95% sequence identity with the full length thereof of a protease domain of an MTSP7 protein, or that hybridize along their full length or along at least about 70%, 80% or 90% of the full length, to a nucleic acid molecule that encodes a protease domain, particularly under conditions of moderate, generally high, stringency.

For the protease domains, residues at the N-terminus can be critical for activity. It is shown herein that the protease domain of the single chain form of the MTSP7 protease is catalytically active. Hence the protease domain will require the N-terminal amino acids; the c-terminus portion can be truncated. The amount that can be removed can be

determined empirically by testing the protein for protease activity in an *in vitro* assays that assesses catalytic cleavage.

Hence smaller portions of the protease domains, particularly the single chain domains, thereof that retain protease activity are contemplated. Such smaller versions will generally be C-terminal truncated versions of the protease domains. The protease domains vary in size and constitution, including insertions and deletions in surface loops. Such domains exhibit conserved structure, including at least one structural feature, such as the active site triad, primary specificity pocket, oxyanion hole and/or other features of serine protease domains of proteases. Thus, for purposes herein, the protease domain is a single chain portion of an MTSP7, as defined herein, but is homologous in its structural features and retention of sequence of similarity or homology the protease domain of chymotrypsin or trypsin. Most significantly, the polypeptide will exhibit proteolytic activity as a single chain.

As used herein, by homologous means about greater than or equal to 25% nucleic acid sequence identity, typically 25% 40%, 60%, 70%, 80%, 85%, 90% or 95% 90% or 95%; the precise percentage can be specified if necessary. For purposes herein the terms "homology" and "identity" are often used interchangeably . In general, for determination of the percentage identity, sequences are aligned so that the highest order match is obtained (see, *e.g.*: *Computational Molecular Biology*, Lesk, A.M., ed., Oxford University Press, New York, 1988; *Biocomputing: Informatics and Genome Projects*, Smith, D.W., ed., Academic Press, New York, 1993; *Computer Analysis of Sequence Data, Part I*, Griffin, A.M., and Griffin, H.G., eds., Humana Press, New Jersey, 1994; *Sequence Analysis in Molecular Biology*, von Heinje, G., Academic Press, 1987; and *Sequence Analysis Primer*, Gribskov, M. and Devereux, J., eds., M Stockton Press, New York, 1991; Carillo *et al.* (1988) *SIAM J Applied Math 48*:1073). By sequence identity, the number of conserved amino acids are determined by standard alignment algorithms

programs, and are used with default gap penalties established by each supplier. Substantially homologous nucleic acid molecules would hybridize typically at moderate stringency or at high stringency all along the length of the nucleic acid of interest. Also contemplated are nucleic acid molecules that contain degenerate codons in place of codons in the hybridizing nucleic acid molecule.

Whether any two nucleic acid molecules have nucleotide sequences that are at least 60%, 70%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% "identical" can be determined using known computer algorithms such as the "FAST A" program, using for example, the default parameters as in Pearson *et al.* (1988) *Proc. Natl. Acad. Sci. USA 85*:2444 (other programs include the GCG program package (Devereux, J., *et al., Nucleic Acids Research 12(I)*:387 (1984)), BLASTP, BLASTN, FASTA (Atschul, S.F., *et al., J Molec Biol 215*:403 (1990); Guide to Huge Computers, Martin J. Bishop, ed., Academic Press, San Diego, 1994, and Carillo *et al.* (1988) *SIAM J Applied Math 48*:1073). For example, the BLAST function of the National Center for Biotechnology Information database can be used to determine identity. Other commercially or publicly available programs include, DNAStar "MegAlign" program (Madison, WI) and the University of Wisconsin Genetics Computer Group (UWG) "Gap" program (Madison WI)). Percent homology or identity of proteins and/or nucleic acid molecules can be determined, for example, by comparing sequence information using a GAP computer program (*e.g.*, Needleman *et al.* (1970) *J. Mol. Biol.* 48:443, as revised by Smith and Waterman ((1981) *Adv. Appl. Math.* 2:482). Briefly, the GAP program defines similarity as the number of aligned symbols (i.e., nucleotides or amino acids) which are similar, divided by the total number of symbols in the shorter of the two sequences. Default parameters for the GAP program can include: (1) a unary comparison matrix (containing a value of 1 for identities and 0 for non-identities) and the weighted comparison matrix of Gribskov *et al.* (1986) *Nucl. Acids Res.* 14:6745, as described by Schwartz and Dayhoff,

eds., *ATLAS OF PROTEIN SEQUENCE AND STRUCTURE*, National Biomedical Research Foundation, pp. 353-358 (1979); (2) a penalty of 3.0 for each gap and an additional 0.10 penalty for each symbol in each gap; and (3) no penalty for end gaps.

Therefore, as used herein, the term "identity" represents a comparison between a test and a reference polypeptide or polynucleotide.

As used herein, the term at least "90% identical to" refers to percent identities from 90 to 99.99 relative to the reference polypeptides. Identity at a level of 90% or more is indicative of the fact that, assuming for exemplification purposes a test and reference polynucleotide length of 100 amino acids are compared. No more than 10% (i.e., 10 out of 100) amino acids in the test polypeptide differs from that of the reference polypeptides. Similar comparisons can be made between a test and reference polynucleotides. Such differences can be represented as point mutations randomly distributed over the entire length of an amino acid sequence or they can be clustered in one or more locations of varying length up to the maximum allowable, e.g. 10/100 amino acid difference (approximately 90% identity). Differences are defined as nucleic acid or amino acid substitutions, or deletions. At the level of homologies or identities above about 85-90%, the result should be independent of the program and gap parameters set; such high levels of identity can be assessed readily, often without relying on software.

As used herein, primer refers to an oligonucleotide containing two or more deoxyribonucleotides or ribonucleotides, generally more than three, from which synthesis of a primer extension product can be initiated. Experimental conditions conducive to synthesis include the presence of nucleoside triphosphates and an agent for polymerization and extension, such as DNA polymerase, and a suitable buffer, temperature and pH.

As used herein, animals include any animal, such as, but are not limited to, goats, cows, deer, sheep, rodents, pigs and humans. Non-

human animals, exclude humans as the contemplated animal. The MTSPs provided herein are from any source, animal, plant, prokaryotic and fungal, such as MTSP7s are of animal origin, including mammalian origin.

As used herein, genetic therapy involves the transfer of heterologous DNA to the certain cells, target cells, of a mammal, particularly a human, with a disorder or conditions for which such therapy is sought. The DNA is introduced into the selected target cells in a manner such that the heterologous DNA is expressed and a therapeutic product encoded thereby is produced. Alternatively, the heterologous DNA can in some manner mediate expression of DNA that encodes the therapeutic product, or it can encode a product, such as a peptide or RNA that in some manner mediates, directly or indirectly, expression of a therapeutic product. Genetic therapy can also be used to deliver nucleic acid encoding a gene product that replaces a defective gene or supplements a gene product produced by the mammal or the cell in which it is introduced. The introduced nucleic acid can encode a therapeutic compound, such as a growth factor inhibitor thereof, or a tumor necrosis factor or inhibitor thereof, such as a receptor therefor, that is not normally produced in the mammalian host or that is not produced in therapeutically effective amounts or at a therapeutically useful time. The heterologous DNA encoding the therapeutic product can be modified prior to introduction into the cells of the afflicted host in order to enhance or otherwise alter the product or expression thereof. Genetic therapy can also involve delivery of an inhibitor or repressor or other modulator of gene expression.

As used herein, heterologous DNA is DNA that encodes RNA and proteins that are not normally produced *in vivo* by the cell in which it is expressed or that mediates or encodes mediators that alter expression of endogenous DNA by affecting transcription, translation, or other regulatable biochemical processes. Heterologous DNA can also be referred to as foreign DNA. Any DNA that one of skill in the art would

recognize or consider as heterologous or foreign to the cell in which is expressed is herein encompassed by heterologous DNA. Examples of heterologous DNA include, but are not limited to, DNA that encodes traceable marker proteins, such as a protein that confers drug resistance, DNA that encodes therapeutically effective substances, such as anti-cancer agents, enzymes and hormones, and DNA that encodes other types of proteins, such as antibodies. Antibodies that are encoded by heterologous DNA can be secreted or expressed on the surface of the cell in which the heterologous DNA has been introduced.

Hence, herein heterologous DNA or foreign DNA, includes a DNA molecule not present in the exact orientation and position as the counterpart DNA molecule found in the genome. It can also refer to a DNA molecule from another organism or species (*i.e.*, exogenous).

As used herein, a therapeutically effective product is a product that is encoded by heterologous nucleic acid, typically DNA, that, upon introduction of the nucleic acid into a host, a product is expressed that ameliorates or eliminates the symptoms, manifestations of an inherited or acquired disease or that cures the disease.

As used herein, recitation that a polypeptide consists essentially of the protease domain means that the only MTSP portion of the polypeptide is a protease domain or a catalytically active portion thereof. The polypeptide can optionally, and generally will, include additional non-MTSP-derived sequences of amino acids.

As used herein, cancer or tumor treatment or agent refers to any therapeutic regimen and/or compound that, when used alone or in combination with other treatments or compounds, can alleviate, reduce, ameliorate, prevent, or place or maintain in a state of remission of clinical symptoms or diagnostic markers associated with deficient angiogenesis.

As used herein, domain refers to a portion of a molecule, *e.g.*, proteins or the encoding nucleic acids, that is structurally and/or functionally distinct from other portions of the molecule.

As used herein, protease refers to an enzyme catalyzing hydrolysis of proteins or peptides. It includes the zymogen form and activated forms thereof. For clarity reference to protease refers to all forms, and particular forms will be specifically designated. For purposes herein, the protease domain includes single and two chain forms of the protease domain of MTSP7.

As used herein, catalytic activity refers to the activity of the MTSP as a protease as assessed in *in vitro* proteolytic assays that detect proteolysis of a selected substrate.

As used herein, nucleic acids include DNA, RNA, dsRNA and anlog thereof, including protein nucleic acids (PNA) and mixture thereof. Nucleic acids can be single or double stranded. When referring to probes or primers, optionally labeled, with a detectable label, such as a fluorescent or radiolabel, single-stranded molecules are contemplated. Such molecules are typically of a length such that target is statistically unique or of low copy number (typically less than 5, generally less than 3) for probing or priming a library. Generally a probe or primer contains at least 14, 16 or 30 contiguous of sequence complementary to or identical a gene of interest. Probes and primers can be 10, 20, 30, 50, 100 or more nucleic acids long.

As used herein, nucleic acid encoding a fragment or portion of an MTSP refers to a nucleic acid encoding only the recited fragment or portion of MTSP, and not the other contiguous portions of the MTSP.

As used herein, heterologous or foreign DNA and RNA are used interchangeably and refer to DNA or RNA that does not occur naturally as part of the genome in which it is present or which is found in a location or locations in the genome that differ from that in which it occurs in nature. Heterologous nucleic acid is generally not endogenous to the cell into which it is introduced, but has been obtained from another cell or prepared synthetically. Generally, although not necessarily, such nucleic acid encodes RNA and proteins that are not normally produced by the cell

in which it is expressed. Any DNA or RNA that one of skill in the art would recognize or consider as heterologous or foreign to the cell in which it is expressed is herein encompassed by heterologous DNA. Heterologous DNA and RNA can also encode RNA or proteins that mediate or alter expression of endogenous DNA by affecting transcription, translation, or other regulatable biochemical processes.

As used herein, operative linkage of heterologous DNA to regulatory and effector sequences of nucleotides, such as promoters, enhancers, transcriptional and translational stop sites, and other signal sequences refers to the relationship between such DNA and such sequences of nucleotides. For example, operative linkage of heterologous DNA to a promoter refers to the physical relationship between the DNA and the promoter such that the transcription of such DNA is initiated from the promoter by an RNA polymerase that specifically recognizes, binds to and transcribes the DNA in reading frame. Thus, as used herein, operatively linked or operationally associated refers to the functional relationship of DNA with regulatory and effector sequences of nucleotides, such as promoters, enhancers, transcriptional and translational stop sites, and other signal sequences. For example, operative linkage of DNA to a promoter refers to the physical and functional relationship between the DNA and the promoter such that the transcription of such DNA is initiated from the promoter by an RNA polymerase that specifically recognizes, binds to and transcribes the DNA. In order to optimize expression and/or *in vitro* transcription, it can be necessary to remove, add or alter 5' untranslated portions of the clones to eliminate extra, potential inappropriate alternative translation initiation (*i.e.*, start) codons or other sequences that can interfere with or reduce expression, either at the level of transcription or translation. Alternatively, consensus ribosome binding sites (see, e.g., Kozak *J. Biol. Chem. 266*:19867-19870 (1991)) can be inserted immediately 5' of the

start codon and can enhance expression. The desirability of (or need for) such modification can be empirically determined.

As used herein, a sequence complementary to at least a portion of an RNA, with reference to antisense oligonucleotides, means a sequence having sufficient complementarily to be able to hybridize with the RNA, generally under moderate or high stringency conditions, forming a stable duplex; in the case of double-stranded MTSP antisense nucleic acids, a single strand of the duplex DNA can thus be tested, or triplex formation can be assayed. The ability to hybridize depends on the degree of complementarily and the length of the antisense nucleic acid. Generally, the longer the hybridizing nucleic acid, the more base mismatches with a MTSP encoding RNA it can contain and still form a stable duplex (or triplex, as the case can be). One skilled in the art can ascertain a tolerable degree of mismatch by use of standard procedures to determine the melting point of the hybridized complex.

For purposes herein, amino acid substitutions can be made in any of MTSPs and protease domains thereof provided that the resulting protein exhibits protease activity. Conservative amino acid substitutions, such as those set forth in Table 1, are those that do not eliminate proteolytic activity. Suitable conservative substitutions of amino acids are known to those of skill in this art and can be made generally without altering the biological activity of the resulting molecule. Those of skill in this art recognize that, in general, single amino acid substitutions in non-essential regions of a polypeptide do not substantially alter biological activity (see, e.g., Watson et al. *Molecular Biology of the Gene*, 4th Edition, 1987, The Bejacmin/Cummings Pub. co., p.224). Also included within the definition, is the catalytically active fragment of an MTSP, particularly a single chain protease portion. Conservative amino acid substitutions are made, for example, in accordance with those set forth in TABLE 1 as follows:

TABLE 1

Original residue	Conservative substitution
Ala (A)	Gly; Ser, Abu
Arg (R)	Lys, orn
Asn (N)	Gln; His
Cys (C)	Ser
Gln (Q)	Asn
Glu (E)	Asp
Gly (G)	Ala; Pro
His (H)	Asn; Gln
Ile (I)	Leu; Val; Met; Nle; Nva
Leu (L)	Ile; Val; Met; Nle; Nv
Lys (K)	Arg; Gln; Glu
Met (M)	Leu; Tyr; Ile; NLe Val
Ornitine	Lys; Arg
Phe (F)	Met; Leu; Tyr
Ser (S)	Thr
Thr (T)	Ser
Trp (W)	Tyr
Tyr (Y)	Trp; Phe
Val (V)	Ile; Leu; Met; Nle; Nv

Other substitutions are also permissible and can be determined empirically or in accord with known conservative substitutions.

As used herein, Abu is 2-aminobutyric acid; Orn is ornithine.

As used herein, the amino acids, which occur in the various amino acid sequences appearing herein, are identified according to their well-known, three-letter or one-letter abbreviations. The nucleotides, which occur in the various DNA fragments, are designated with the standard single-letter designations used routinely in the art.

As used herein, a splice variant refers to a variant produced by differential processing of a primary transcript of genomic DNA that results in more than one type of mRNA.

As used herein, a probe or primer based on a nucleotide sequence disclosed herein, includes at least 10, 14, generally at least 16 or 30 or 100 contiguous sequence of nucleotides of SEQ ID No. 15, except for a region that includes the sequence that encodes amino acids 117-171 and 185-354 of SEQ ID Nos 15 and 16.

As used herein, amelioration of the symptoms of a particular disorder by administration of a particular pharmaceutical composition

refers to any lessening, whether permanent or temporary, lasting or transient that can be attributed to or associated with administration of the composition.

As used herein, antisense polynucleotides refer to synthetic sequences of nucleotide bases complementary to mRNA or the sense strand of double stranded DNA. Admixture of sense and antisense polynucleotides under appropriate conditions leads to the binding of the two molecules, or hybridization. When these polynucleotides bind to (hybridize with) mRNA, inhibition of protein synthesis (translation) occurs. When these polynucleotides bind to double-stranded DNA, inhibition of RNA synthesis (transcription) occurs. The resulting inhibition of translation and/or transcription leads to an inhibition of the synthesis of the protein encoded by the sense strand. Antisense nucleic acid molecule typically contain a sufficient number of nucleotides to specifically bind to a target nucleic acid, generally at least 5 contiguous nucleotides, often at least 14 or 16 or 30 contiguous nucleotides or modified nucleotides complementary to the coding portion of a nucleic acid molecule that encodes a gene of interest, for example, nucleic acid encoding a single chain protease domain of an MTSP.

As used herein, an array refers to a collection of elements, such as antibodies, containing three or more members. An addressable array is one in which the members of the array are identifiable, typically by position on a solid phase support. Hence, in general the members of the array will be immobilized to discrete identifiable loci on the surface of a solid phase.

As used herein, antibody refers to an immunoglobulin, whether natural or partially or wholly synthetically produced, including any derivative thereof that retains the specific binding ability the antibody. Hence antibody includes any protein having a binding domain that is homologous or substantially homologous to an immunoglobulin binding

domain. Antibodies include members of any immunoglobulin claims, including IgG, IgM, IgA, IgD and IgE.

As used herein, antibody fragment refers to any derivative of an antibody that is less then full length, retaining at least a portion of the full-length antibody's specific binding ability. Examples of antibody fragments include,but are not limited to, Fab, Fab', $F(ab)_2$, single-chain Fvs (scFV), FV, dsFV diabody and Fd fragments. The fragment can include multiple chains linked together, such as by disulfide bridges. An antibody fragment generally contains at least about 50 amino acids and typically at least 200 amino acids.

As used herein, an Fv antibody fragment is composed of one variable heavy domain (V_H) and one variable light domain linked by noncovalent interactions.

As used herein, a dsFV refers to an Fv with an engineered intermolecular disulfide bond, which stabilizes the V_H-V_L pair.

As used herein, an $F(ab)_2$ fragment is an antibody fragment that results from digestion of an immunoglobulin with pepsin at pH 4.0-4.5; it can be recombinantly produce the equivalent fragment.

As used herein, Fab fragments is an antibody fragment that results from digestion of an immunoglobulin with papain; it can be recombinantly produce the equivalent fragment.

As used herein, scFVs refer to antibody fragments that contain a variable light chain (V_L) and variable heavy chain (V_H) covalently connected by a polypeptide linker in any order. The linker is of a length such that the two variable domains are bridged without substantial interference. Exemplary linkers include $(Gly\text{-}Ser)_n$ residues with some Glu or Lys residues dispersed throughout to increase solubility.

As used herein, humanized antibodies refer to antibodies that are modified to include human sequences of amino acids so that administration to a human will not provoke an immune response. Methods for preparation of such antibodies are known. For example, the

hybridoma that expresses the monoclonal antibody is altered by recombinant DNA techniques to express an antibody in which the amino acid composition of the non-variable regions is based on human antibodies. Computer programs have been designed to identify such regions.

As used herein, diabodies are dimeric scFV; diabodies typically have shorter peptide linkers than scFvs, and they typically dimerize.

As used herein the term assessing is intended to include quantitative and qualitative determination in the sense of obtaining an absolute value for the activity of an MTSP, or a domain thereof, present in the sample, and also of obtaining an index, ratio, percentage, visual or other value indicative of the level of the activity. Assessment can be direct or indirect and the chemical species actually detected need not of course be the proteolysis product itself but can for example be a derivative thereof or some further substance.

As used herein, biological activity refers to the in vivo activities of a compound or physiological responses that result upon in vivo administration of a compound, composition or other mixture. Biological activity, thus, encompasses therapeutic effects and pharmaceutical activity of such compounds, compositions and mixtures. Biological activities can be observed in in vitro systems designed to test or use such activities. Thus, for purposes herein the biological activity of a luciferase is its oxygenase activity whereby, upon oxidation of a substrate, light is produced.

As used herein, a combination refers to any association between two or among more items.

As used herein, a composition refers to a any mixture. It can be a solution, a suspension, liquid, powder, a paste, aqueous, non-aqueous or any combination thereof.

As used herein, a conjugate refers to the compounds provided herein that include one or more MTSPs, including an MTSP7, particularly single chain protease domains thereof, and one or more targeting agents. These conjugates include those produced by recombinant means as fusion proteins, those produced by chemical means, such as by chemical coupling, through, for example, coupling to sulfhydryl groups, and those produced by any other method whereby at least one MTSP, or a domain thereof, is linked, directly or indirectly via linker(s) to a targeting agent.

As used herein, a targeting agent, is any moiety, such as a protein or effective portion thereof, that provides specific binding of the conjugate to a cell surface receptor, which, in certain embodiments internalizes the conjugate or MTSP portion thereof. A targeting agent can also be one that promotes or facilitates, for example, affinity isolation or purification of the conjugate; attachment of the conjugate to a surface; or detection of the conjugate or complexes containing the conjugate.

As used herein, an antibody conjugate refers to a conjugate in which the targeting agent is an antibody.

As used herein, derivative or analog of a molecule refers to a portion derived from or a modified version of the molecule.

As used herein, fluid refers to any composition that can flow. Fluids thus encompass compositions that are in the form of semi-solids, pastes, solutions, aqueous mixtures, gels, lotions, creams and other such compositions.

As used herein, an effective amount of a compound for treating a particular disease is an amount that is sufficient to ameliorate, or in some manner reduce the symptoms associated with the disease. Such amount can be administered as a single dosage or can be administered according to a regimen, whereby it is effective. The amount can cure the disease but, typically, is administered in order to ameliorate the symptoms of the disease. Repeated administration can be required to achieve the desired amelioration of symptoms.

As used herein equivalent, when referring to two sequences of nucleic acids means that the two sequences in question encode the same sequence of amino acids or equivalent proteins. When equivalent is used in referring to two proteins or peptides, it means that the two proteins or peptides have substantially the same amino acid sequence with only conservative amino acid substitutions (see, *e.g.*, Table 1, above) that do not substantially alter the activity or function of the protein or peptide. When equivalent refers to a property, the property does not need to be present to the same extent [e.g., two peptides can exhibit different rates of the same type of enzymatic activity], but the activities are generally substantially the same. Complementary, when referring to two nucleotide sequences, means that the two sequences of nucleotides are capable of hybridizing, generally with less than 25%,less than 15%, and even less than 5%, including with no mismatches between opposed nucleotides. Generally the two molecules will hybridize under conditions of high stringency.

As used herein, an agent that modulates the activity of a protein or expression of a gene or nucleic acid either decreases or increases or otherwise alters the activity of the protein or, in some manner up- or down-regulates or otherwise alters expression of the nucleic acid in a cell.

As used herein, inhibitor of an activity of an MTSP encompasses any substances that prohibit or decrease production, post-translational modification(s), maturation, or membrane localization of the MTSP or any substances that interfere with or decrease the proteolytic efficacy of thereof, particularly of a single chain form *in vitro* for screeing assay.

As used herein, a method for treating or preventing neoplastic disease means that any of the symptoms, such as the tumor, metastasis thereof, the vascularization of the tumors or other parameters by which the disease is characterized are reduced, ameliorated, prevented, placed in a state of remission, or maintained in a state of remission. It also means that the hallmarks of neoplastic disease and metastasis can be

eliminated, reduced or prevented by the treatment. Non-limiting examples of the hallmarks include uncontrolled degradation of the basement membrane and proximal extracellular matrix, migration, division, and organization of the endothelial cells into new functioning capillaries, and the persistence of such functioning capillaries.

As used herein, pharmaceutically acceptable salts, esters or other derivatives of the conjugates include any salts, esters or derivatives that can be readily prepared by those of skill in this art using known methods for such derivatization and that produce compounds that can be administered to animals or humans without substantial toxic effects and that either are pharmaceutically active or are prodrugs.

As used herein, a prodrug is a compound that, upon in vivo administration, is metabolized or otherwise converted to the biologically, pharmaceutically or therapeutically active form of the compound. To produce a prodrug, the pharmaceutically active compound is modified such that the active compound will be regenerated by metabolic processes. The prodrug can be designed to alter the metabolic stability or the transport characteristics of a drug, to mask side effects or toxicity, to improve the flavor of a drug or to alter other characteristics or properties of a drug. By virtue of knowledge of pharmacodynamic processes and drug metabolism in vivo, those of skill in this art, once a pharmaceutically active compound is known, can design prodrugs of the compound (see, e.g., Nogrady (1985) Medicinal Chemistry A Biochemical Approach, Oxford University Press, New York, pages 388-392).

As used herein, a drug identified by the screening methods provided herein refers to any compound that is a candidate for use as a therapeutic or as lead compound for design of a therapeutic. Such compounds can be small molecules, including small organic molecules, peptides, peptide mimetics, antisense molecules or dsRNA, such as RNAi,, antibodies, fragments of antibodies, recombinant antibodies and

other such compound which can serve as drug candidate or lead compound.

As used herein, a peptidomimetic is a compound that mimics the conformation and certain stereochemical features of the biologically active form of a particular peptide. In general, peptidomimetics are designed to mimic certain desirable properties of a compound, but not the undesirable properties, such as flexibility, that lead to a loss of a biologically active conformation and bond breakdown. Peptidomimetics may be prepared from biologically active compounds by replacing certain groups or bonds that contribute to the undesirable properties with bioisosteres. Bioisosteres are known to those of skill in the art. For example the methylene bioisostere CH_2S has been used as an amide replacement in enkephalin analogs (see, e.g., Spatola (1983) pp. 267-357 in Chemistry and Blochemistry of Amino Acids, Peptides, and Proteins, Weistein, Ed. volume 7, Marcel Dekker, New York). Morphine, which can be administered orally, is a compound that is a peptidomimetic of the peptide endorphin. For purposes herein, cyclic peptides are included among pepidomimetics.

As used herein, production by recombinant means by using recombinant DNA methods means the use of the well known methods of molecular biology for expressing proteins encoded by cloned DNA.

As used herein, a promoter region or promoter element refers to a segment of DNA or RNA that controls transcription of the DNA or RNA to which it is operatively linked. The promoter region includes specific sequences that are sufficient for RNA polymerase recognition, binding and transcription initiation. This portion of the promoter region is often referred to as the promoter. In addition, the promoter region includes sequences that modulate this recognition, binding and transcription initiation activity of RNA polymerase. These sequences can be *cis* acting or can be responsive to *trans* acting factors. Promoters, depending upon the nature of the regulation, can be constitutive or regulated. Exemplary

promoters contemplated for use in prokaryotes include the bacteriophage T7 and T3 promoters.

As used herein, a receptor refers to a molecule that has an affinity for a given ligand. Receptors can be naturally-occurring or synthetic molecules. Receptors can also be referred to in the art as anti-ligands. As used herein, the receptor and anti-ligand are interchangeable. Receptors can be used in their unaltered state or as aggregates with other species. Receptors can be attached, covalently or noncovalently, or in physical contact with, to a binding member, either directly or indirectly via a specific binding substance or linker. Examples of receptors, include, but are not limited to: antibodies, cell membrane receptors surface receptors and internalizing receptors, monoclonal antibodies and antisera reactive with specific antigenic determinants [such as on viruses, cells, or other materials], drugs, polynucleotides, nucleic acids, peptides, cofactors, lectins, sugars, polysaccharides, cells, cellular membranes, and organelles.

Examples of receptors and applications using such receptors, include but are not restricted to:

a) enzymes: specific transport proteins or enzymes essential to survival of microorganisms, which could serve as targets for antibiotic (ligand) selection;

b) antibodies: identification of a ligand-binding site on the antibody molecule that combines with the epitope of an antigen of interest can be investigated; determination of a sequence that mimics an antigenic epitope can lead to the development of vaccines of which the immunogen is based on one or more of such sequences or lead to the development of related diagnostic agents or compounds useful in therapeutic treatments such as for auto-immune diseases

c) nucleic acids: identification of ligand, such as protein or RNA, binding sites;

d) catalytic polypeptides: polymers, generally polypeptides, that are capable of promoting a chemical reaction involving the conversion of one or more reactants to one or more products; such polypeptides generally include a binding site specific for at least one reactant or reaction intermediate and an active functionality proximate to the binding site, in which the functionality is capable of chemically modifying the bound reactant (see, e.g., U.S. Patent No. 5,215,899);

e) hormone receptors: determination of the ligands that bind with high affinity to a receptor is useful in the development of hormone replacement therapies; for example, identification of ligands that bind to such receptors can lead to the development of drugs to control blood pressure; and

f) opiate receptors: determination of ligands that bind to the opiate receptors in the brain is useful in the development of less-addictive replacements for morphine and related drugs.

As used herein, sample refers to anything which can contain an analyte for which an analyte assay is desired. The sample can be a biological sample, such as a biological fluid or a biological tissue. Examples of biological fluids include urine, blood, plasma, serum, saliva, semen, stool, sputum, cerebral spinal fluid, tears, mucus, amniotic fluid or the like. Biological tissues are aggregate of cells, usually of a particular kind together with their intercellular substance that form one of the structural materials of a human, animal, plant, bacterial, fungal or viral structure, including connective, epithelium, muscle and nerve tissues. Examples of biological tissues also include organs, tumors, lymph nodes, arteries and individual cell(s).

As used herein: stringency of hybridization in determining percentage mismatch is as follows:

1) high stringency: 0.1 x SSPE, 0.1% SDS, 65°C
2) medium stringency: 0.2 x SSPE, 0.1% SDS, 50°C
3) low stringency: 1.0 x SSPE, 0.1% SDS, 50°C

Those of skill in this art know that the washing step selects for stable hybrids and also know the ingredients of SSPE (see, e.g., Sambrook, E.F. Fritsch, T. Maniatis, in: Molecular Cloning, A Laboratory Manual, Cold Spring Harbor Laboratory Press (1989), vol. 3, p. B.13, see, also, numerous catalogs that describe commonly used laboratory solutions). SSPE is pH 7.4 phosphate- buffered 0.18 NaCl. Further, those of skill in the art recognize that the stability of hybrids is determined by T_m, which is a function of the sodium ion concentration and temperature (T_m = 81.5° C-16.6($\log_{10}[Na^+]$) + 0.41(%G+C)-600/l)), so that the only parameters in the wash conditions critical to hybrid stability are sodium ion concentration in the SSPE (or SSC) and temperature.

It is understood that equivalent stringencies can be achieved using alternative buffers, salts and temperatures. By way of example and not limitation, procedures using conditions of low stringency are as follows (see also Shilo and Weinberg, *Proc. Natl. Acad. Sci. USA*, 78:6789-6792 (1981)): Filters containing DNA are pretreated for 6 hours at 40°C in a solution containing 35% formamide, 5X SSC, 50 mM Tris-HCl (pH 7.5), 5 mM EDTA, 0.1% PVP, 0.1% Ficoll, 1% BSA, and 500 μg/ml denatured salmon sperm DNA (10X SSC is 1.5 M sodium chloride, and 0.15 M sodium citrate, adjusted to a pH of 7).

Hybridizations are carried out in the same solution with the following modifications: 0.02% PVP, 0.02% Ficoll, 0.2% BSA, 100 μg/ml salmon sperm DNA, 10% (wt/vol) dextran sulfate, and 5-20 X 10^6 cpm ^{32}P-labeled probe is used. Filters are incubated in hybridization mixture for 18-20 hours at 40°C, and then washed for 1.5 hours at 55°C in a solution containing 2X SSC, 25 mM Tris-HCl (pH 7.4), 5 mM EDTA, and 0.1% SDS. The wash solution is replaced with fresh solution and incubated an additional 1.5 hours at 60°C. Filters are blotted dry and exposed for autoradiography. If necessary, filters are washed for a third time at 65-68°C and reexposed to film. Other conditions of low

stringency which can be used are well known in the art (*e.g.*, as employed for cross-species hybridizations).

By way of example and not way of limitation, procedures using conditions of moderate stringency is provided. For example, but not limited to, procedures using such conditions of moderate stringency are as follows: Filters containing DNA are pretreated for 6 hours at 55°C in a solution containing 6X SSC, 5X Denhart's solution, 0.5% SDS and 100 μg/ml denatured salmon sperm DNA. Hybridizations are carried out in the same solution and 5-20 X 10^6 cpm ^{32}P-labeled probe is used. Filters are incubated in hybridization mixture for 18-20 hours at 55°C, and then washed twice for 30 minutes at 60°C in a solution containing 1X SSC and 0.1% SDS. Filters are blotted dry and exposed for autoradiography. Other conditions of moderate stringency which can be used are well-known in the art. Washing of filters is done at 37°C for 1 hour in a solution containing 2X SSC, 0.1% SDS.

By way of example and not way of limitation, procedures using conditions of high stringency are as follows: Prehybridization of filters containing DNA is carried out for 8 hours to overnight at 65°C in buffer composed of 6X SSC, 50 mM Tris-HCl (pH 7.5), 1 mM EDTA, 0.02% PVP, 0.02% Ficoll, 0.02% BSA, and 500 μg/ml denatured salmon sperm DNA. Filters are hybridized for 48 hours at 65°C in prehybridization mixture containing 100 μg/ml denatured salmon sperm DNA and 5-20 X 10^6 cpm of ^{32}P-labeled probe. Washing of filters is done at 37°C for 1 hour in a solution containing 2X SSC, 0.01% PVP, 0.01% Ficoll, and 0.01% BSA. This is followed by a wash in 0.1X SSC at 50°C for 45 minutes before autoradiography. Other conditions of high stringency which can be used are well known in the art.

The term substantially identical or homologous or similar varies with the context as understood by those skilled in the relevant art and generally means at least 70%, at least 80%, at least 90%, and generally

at least 95% identity. The percentage will be apparent from the context or can be specified.

As used herein, substantially identical to a product means sufficiently similar so that the property of interest is sufficiently unchanged so that the substantially identical product can be used in place of the product.

As used herein, substantially pure means sufficiently homogeneous to appear free of readily detectable impurities as determined by standard methods of analysis, such as thin layer chromatography (TLC), gel electrophoresis and high performance liquid chromatography (HPLC), used by those of skill in the art to assess such purity, or sufficiently pure such that further purification would not detectably alter the physical and chemical properties, such as enzymatic and biological activities, of the substance. Methods for purification of the compounds to produce substantially chemically pure compounds are known to those of skill in the art. A substantially chemically pure compound can, however, be a mixture of stereoisomers or isomers. In such instances, further purification might increase the specific activity of the compound.

As used herein, target cell refers to a cell that expresses an MTSP *in vivo*.

As used herein, test substance refers to a chemically defined compound (*e.g.*, organic molecules, inorganic molecules, organic/inorganic molecules, proteins, peptides, nucleic acids, oligonucleotides, lipids, polysaccharides, saccharides, or hybrids among these molecules such as glycoproteins) or mixtures of compounds (*e.g.*, a library of test compounds, natural extracts or culture supernatants) whose effect on an MTSP, particularly a single chain form that includes the protease domain or a sufficient portion thereof for activity, as determined by *in vitro* method, such as the assays provided herein.

As used herein, the terms a therapeutic agent, therapeutic regimen, radioprotectant, chemotherapeutic mean conventional drugs and drug

therapies, including vaccines, which are known to those skilled in the art. Radiotherapeutic agents are well known in the art.

As used herein, treatment means any manner in which the symptoms of a conditions, disorder or disease are ameliorated or otherwise beneficially altered. Treatment also encompasses any pharmaceutical use of the compositions herein.

As used herein, vector (or plasmid) refers to discrete elements that are used to introduce heterologous DNA into cells for either expression or replication thereof. The vectors typically remain episomal, but can be designed to effect integration of a gene or portion thereof into a chromosome of the genome. Also contemplated are vectors that are artificial chromosomes, such as yeast artificial chromosomes and mammalian artificial chromosomes. Selection and use of such vehicles are well known to those of skill in the art. An expression vector includes vectors capable of expressing DNA that is operatively linked with regulatory sequences, such as promoter regions, that are capable of effecting expression of such DNA fragments. Thus, an expression vector refers to a recombinant DNA or RNA construct, such as a plasmid, a phage, recombinant virus or other vector that, upon introduction into an appropriate host cell, results in expression of the cloned DNA. Appropriate expression vectors are well known to those of skill in the art and include those that are replicable in eukaryotic cells and/or prokaryotic cells and those that remain episomal or those which integrate into the host cell genome.

As used herein, protein binding sequence refers to a protein or peptide sequence that is capable of specific binding to other protein or peptide sequences generally, to a set of protein or peptide sequences or to a particular protein or peptide sequence.

As used herein, epitope tag refers to a short stretch of amino acid residues corresponding to an epitope to facilitate subsequent biochemical and immunological analysis of the epitope tagged protein or peptide.

Epitope tagging is achieved by including the sequence of the epitope tag to the protein-encoding sequence in an appropriate expression vector. Epitope tagged proteins can be affinity purified using highly specific antibodies raised against the tags.

As used herein, metal binding sequence refers to a protein or peptide sequence that is capable of specific binding to metal ions generally, to a set of metal ions or to a particular metal ion.

As used herein, a cellular extract refers to a preparation or fraction which is made from a lysed or disrupted cell.

As used herein, an agent is said to be randomly selected when the agent is chosen randomly without considering the specific sequences involved in the association of a protein alone or with its associated substrates and binding partners. An example of randomly selected agents is the use a chemical library or a peptide combinatorial library, or a growth broth of an organism or condition medium.

As used herein, an agent is said to rationally selected or designed when the agent is chosen on a non-random basis which takes into account the sequence of the target site and/or its conformation in connection with the agent's action. As described in the Examples, there are proposed binding sites for serine protease and (catalytic) sites in the protein having SEQ ID NO:3 or SEQ ID NO:4. Agents can be rationally selected or rationally designed by utilizing the peptide sequences that make up these sites. For example, a rationally selected peptide agent can be a peptide whose amino acid sequence is identical to the ATP or calmodulin binding sites or domains.

For clarity of disclosure, and not by way of limitation, the detailed description is divided into the subsections that follow.

B. MTSP7 PROTEINS, MUTEINS, DERIVATIVES AND ANALOGS THEREOF

MTSPs

The MTSPs are a family of transmembrane serine proteases that are found in mammals and also other species that share a number of common structural features including: a proteolytic extracellular C-terminal domain; a transmembrane domain, with a hydrophobic domain near the N-terminus; a short cytoplasmic domain; and a variable length stem region containing modular domains. The proteolytic domains share sequence homologoy including conserved his, asp, and ser residues necessary for catalytic activity that are present in conserved motifs. The MTSPs are synthesized as zymogens, and activated to two chain forms by cleavage. It is shown herein that the single chain proteolytic domain can function *in vitro* and, hence is useful in *in vitro* assays for identifying agents that modulate the activity of members of this family.

The MTSP family is a target for therapeutic intervention and also some members can serve as diagnostic markers for tumor development, growth and/or progression. As discussed, the members of this family are involved in proteolytic processes that are implicated in tumor development, growth and/or progression. This implication is based upon their functions as proteolytic enzymes in processes related to ECM degradative pathways. In addition, their levels of expression or level of activation or their apparent activity resulting from substrate levels or alterations in substrates and levels thereof differs in tumor cells and non-tumor cells in the same tissue. Hence, protocols and treatments that alter their activity, such as their proteolytic activities and roles in signal transduction, and/or their expression, such as by contacting them with a compound that modulates their activity and/or expression, could impact tumor development, growth and/or progression. Also, in some instances, the level of activation and/or expression can be altered in

tumors, such as lung carcinoma, colon adenocarcinoma and ovarian carcinoma.

MTSPs are of interest because they appear to be expressed and/or activated at different levels in tumor cells from normal cells, or have functional activity that is different in tumor cells from normal cells, such as by an alteration in a substrate therefor, or a cofactor.

MTSP7

Isolated, substantially pure proteases that include protease domains or a catalytically active portion thereof in single chain form of MTSPs also are provided. Provided is the family member designated MTSP7. The protease domains can be included in a longer protein, and such longer protein is optionally the MTSP7 zymogen. MTSP7 is of interest because it is expressed or is active in tumor cells. Hence the MTSP provided herein can serve as diagnostic markers for certain tumors. The level of activated MTSP7 can be diagnostic of cancers, including cervical or lung cancer or leukemia.

It is shown herein, that MTSP7s provided herein are expressed and/or activated in certain tumors; hence their activation or expression can serve as a diagnostic marker for tumor development, growth and/or progression. In other instances the MTSP protein can exhibit altered activity by virtue of a change in activity or expression of a co-factor therefor or a substrate therefor. In addition, in some instances, these MTSPS and/or variants thereof can be shed from cell surfaces. Detection of the shed MTSPS, particularly the extracellular domains, in body fluids, such as serum, blood, saliva, cerebral spinal fluid, synovial fluid and interstitial fluids, urine, sweat and other such fluids and secretions, can serve as a diagnostic tumor marker. In particular, detection of higher levels of such shed polypeptides in a subject compared to a subject known not to have any neoplastic disease or compared to earlier samples from the same subject, can be indicative of neoplastic disease in the subject.

The protease domains of an MTSP are single-chain polypeptides, with an N-terminus (such as IV, VV, IL and II) generated at the cleavage site (generally having the consensus sequence R↓VVGG, R↓IVGG, R↓IVQ, R↓IVNG, R↓ILGG, R↓VGLL, R↓ILGG or a variation thereof; an N-terminus R↓V or R↓I, where the arrow represents the cleavage point) when the zymogen is activated. The protease domain of MTSP7, produced by cleavage (R↓I) includes the sequence IVNG, is set forth in SEQ ID Nos. 17 and 18.

The protease domain of the MTSP does not have to result from activation, which produces a two chain activated product, but rather includes single chain polypeptides with the N-terminus include the consensus sequence ↓VVGG, ↓IVGG, ↓VGLL, ↓ILGG, ↓IVQG or ↓IVNG or other such motif at the N-terminus. Such polypeptides, although not the result of activation and not two-chain forms, exhibit proteolytic (catalytic) activity. These protease domain polypeptides are used in assays to screen for agents that modulate the activity of the MTSP7.

The domains, fragments, derivatives or analogs of an MTSP7 that are functionally active are capable of exhibiting one or more functional activities associated with the MTSP7 protein, such as serine protease activity, immunogenicity and antigenicity, are provided.

Polypeptides and muteins

Provided herein are isolated substantially pure single polypeptides that contain the protease domain of an MTSP7 as a single chain. The protein can also include other non-MTSP sequences of amino acids, but will include the protease domain or a sufficient portion thereof to exhibit catalytic activity in any *in vitro* assay that assess such protease activity, such as any provided herein.

MTSP7 polypeptides provided herein are expressed on or active in or on tumor cells, typically at a level that differs from the level in which they are expressed or active in the non-tumor cell of the same type. Hence, for example, if the MTSP is expressed in an ovarian tumor cell, it

is expressed or active at a different level in non-tumor ovarian cells. MTSP protease domains include the single chain protease domains of MTSP7.

Also provided herein are nucleic acid molecules that encode MTSP proteins and the encoded proteins. In particular, nucleic acid molecules encoding MTSP7 from animals, including splice variants thereof are provided. The encoded proteins are also provided. Also provided are functional domains thereof.

In specific aspects, the MTSP protease domains, portions thereof, and muteins thereof are from or based on animal MTSPS, including, but are not limited to, rodent, such as mouse and rat; fowl, such as chicken; ruminants, such as goats, cows, deer, sheep; ovine, such as pigs; and humans. In particular, MTSP7 derivatives can be made by altering their sequences by substitutions, additions or deletions. Due to the degeneracy of nucleotide coding sequences, other nucleic sequences which encode substantially the same amino acid sequence as a MTSP7 gene can be used. These include but are not limited to nucleotide sequences comprising all or portions of MTSP7 genes that are altered by the substitution of different codons that encode the amino acid residue within the sequence, thus producing a silent change. Likewise, the MTSP7 derivatives include, but are not limited to, those containing, as a primary amino acid sequence, all or part of the amino acid sequence of MTSP7, including altered sequences in which functionally equivalent amino acid residues are substituted for residues within the sequence resulting in a silent change. For example, one or more amino acid residues within the sequence can be substituted by another amino acid of a similar polarity which acts as a functional equivalent, resulting in a silent alteration. Substitutes for an amino acid within the sequence can be selected from other members of the class to which the amino acid belongs. For example, the nonpolar (hydrophobic) amino acids include alanine, leucine, isoleucine, valine, proline, phenylalanine, tryptophan and

methionine. The polar neutral amino acids include glycine, serine, threonine, cysteine, tyrosine, asparagine, and glutamine. The positively charged (basic) amino acids include arginine, lysine and histidine. The negatively charged (acidic) amino acids include aspartic acid and glutamic acid (see, *e.g.*, Table 1). Muteins of the MTSP7 or a domain thereof, such as a protease domain, in which up to about 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 85%, 90% or 95% of the amino acids are replaced with another amino acid are provided. Generally such muteins retain at least about 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80% or 90% of the protease activity the unmutated protein.

Also provided are peptides that are encoded by the nucleic acid molecules described herein. Included among those polypeptides are the MTSP7 protease domain or a polypeptide with amino acid changes such that the specificity and protease activity remains substantially unchanged or changed (increased or decreased) by a specified percentage, such as 10, 20, 30, 40, 50%. In particular, a substantially purified mammalian MTSP protein is provided that has a transmembrane domain and can additionally include a transmembrane (TM) domain, a SEA domain and a serine protease catalytic domain is provided.

Also provided is a substantially purified protein containing a sequence of amino acids that has at least 60%, at least about 80%, at least about 90% or at least about 95%, identity to the MTSP7 where the percentage identity is determined using standard algorithms and gap penalties that maximize the percentage identity. The human MTSP7 protein is included, although other mammalian MTSP7 proteins are contemplated. The precise percentage of identity can be specified if needed.

Predicted disulfide bonds pairing in MTSP7 is Cys233 to Cys249; Cys358 to Cys374; Cys385 to Cys413 and Cys186 to Cys313. The Cys313 is in the protease domain and is unpaired in the single chain form of the protease domain. Muteins of MTSP7, particularly those in which

Cys residues, such as the Cys313 in the single chain protease domain, is replaced with another amino acid, such as Ser, Gly or Ala, that does not eliminate the activity, are provided.

Also provided are substantially purified MTSP7 polypeptides and functional domains thereof, including catalytically active domains and portions, that have at least about 60%, 70%, 80%, 85%, 90% or 95% sequence identity with a protease domain that includes the sequence of amino acids set forth in SEQ ID No. 16 or a catalytically active portion thereof or with a protease that includes the sequence of amino acids set forth in SEQ ID No. 18 and domains thereof.

In particular, exemplary protease domains include at least a sufficient portion of sequences of amino acids set forth as amino acids 206-438 in SEQ ID No. 16 (encoded by nucleotides in SEQ ID No. 15 and 17; see also the Figure).

Also contemplated are nucleic acid molecules that encode a single chain MTSP protease that have proteolytic activity in an *in vitro* proteolysis assay and that have at least 60%, 70%, 80%, 85%, 90% or 95% sequence identity with the full length of a protease domain of an MTSP7 protein, or that hybridize along their full length to a nucleic acids that encode a protease domain, particularly under conditions of moderate, generally high, stringency. As above, the encoded polypeptides contain the protease as a single chain.

Muteins of the protein are also provided in which amino acids are replaced with other amino acids. Among the muteins are those in which the Cys residues, is/are replaced typically with a conservative amino acid residues, such as a serine. Such muteins are also provided herein. Muteins in which 10%, 20%, 30%, 35%, 40%, 45%, 50% or more of the amino acids are replaced but the resulting polypeptide retains at least about 10%, 20%, 30%, 35%, 40%, 45%, 50%, 60%, 70%, 80%, 90% or 95% of the catalytic activity as the unmodified form for the same substrate.

Muteins can be made by making conservative amino acid substitions and also non-conservative amino acid substitutions. For example, amino acid substitutions the desirably alter properties of the proteins can be made. In one embodiment, mutations that prevent degradation of the polypeptide can be made. Many proteases cleave after basic residues, such as R and K; to eliminate such cleavage, the basic residue is replaced with a non-basic residue. Interaction of the protease with an inhibitor can be blocked while retaining catalytic activity by effecting a non-conservative change at the site interaction of the inhibitor with the protease. Receptor binding can be altered without altering catalytic activity.

Nucleic acids

In one embodiment, the substantially purified MTSP protease is encoded by a nucleic acid that hybridizes to the a nucleic acid molecule containing the protease domain encoded by the nucleotide sequence set forth in any of SEQ. ID Nos. 15 and 17 under at least moderate, generally high, stringency conditions, such that the protease domain encoding nucleic acid thereof hybridizes along its full length or at least 70%, 80% or 90% of the full length. In certain embodiments the substantially purified MTSP protease is a single chain polypeptide that includes substantially the sequence of amino acids set forth in SEQ ID No. 2, 16 or the protease domain portion thereof, or a catalytically active portion thereof. Figures 1 depicts the structural organization of the MTSP7.

In a specific embodiment, a nucleic acid that encodes a MTSP, designated MTSP7 is provided. In particular, the nucleic acid includes an open reading frame within the following sequence of nucleotides set forth in SEQ ID No. 15. In particular the protein is encoded by the open reading frame that begins at nucleotide 48 check and ends at 1360). Also provided are nucleic acid molecules that hybridize under conditions of at least low stringency, moderate stringency, and generally high stringency to the following sequence of nucleic acids (SEQ ID No. 15),

particularly to the open reading frame encompassed by nucleotides that encode a single protease domain thereof, or any domain of MTSP7.

Also included are substantially purified MTSP7 zymogen, activated two chain forms, single chain protease domains and two chain protease domains. These are encoded by a nucleic acid that includes sequence encoding a protease domain that exhibits proteolytic activity and that hybridizes to a nucleic acid molecule having a nucleotide sequence set forth in SEQ ID No. 15, typically under moderate, generally under high stringency, conditions and generally along the full length (or substantially the full length) of the protease domain. Splice variants are also contemplated herein.

In certain embodiments, the isolated nucleic acid fragment hybridizes to the nucleic acid having the nucleotide sequence set forth in SEQ ID No: 15 (or the molecules in the figure in the FIGURE) under high stringency conditions, and generally contains the sequence of nucleotides set forth in SEQ ID Nos. 15-17; see also the Figure). The protein contains a transmembrane domain (TM), a SEA domain and a serine protease domain. Muteins of the protein are also provided in which amino acids are replaced with conservative amino acids. Among the muteins are those in which the Cys residues, is/are replaced with generally conservative amino acid residues, such as a serine. Such muteins are also provided herein. Each of such domains is provided herein as are nucleic acid molecules that include sequences of nucleotides encoding such domains. Some MTSPs can additionally include a LDLR domain, a scavenger-receptor cysteine rich (SRCR) domain and other domains.

The isolated nucleic acid fragment is DNA, including genomic or cDNA, or is RNA, or can include other components, such as protein nucleic acid. The isolated nucleic acid can include additional components, such as heterologous or native promoters, and other transcriptional and translational regulatory sequences, these genes can be linked to other

genes, such as reporter genes or other indicator genes or genes that encode indicators.

Also provided is an isolated nucleic acid molecule that includes the sequence of molecules that is complementary to the nucleotide sequence encoding MTSP7 or the portion thereof.

Also provided are fragments thereof that can be used as probes or primers and that contain at least about 10 nucleotides, 14 nucleotides, generally at least about 16 nucleotides, often at least about 30 nucleotides. The length of the probe or primer is a function of the size of the genome probed; the larger the genome, the longer the probe or primer required for specific hybridization to a single site. Those of skill in the art can select appropriately sized probes and primers. Generally probes and primers as described are single-stranded. Double stranded probes and primers can be used, if they are denatured when used.

Also provided are nucleic acid molecules that hybridize to the above-noted sequences of nucleotides encoding MTSP7 at least at low stringency, moderate stringency, and typically at high stringency, and that encode the protease domain and/or the full length protein or at least 70%, 80% or 90% of the full length or other domains of an MTSP7 or a splice variant or allelic variant thereof. Generally the molecules hybridize under such conditions along their full length or at least 70%, 80% or 90% of the full length for at least one domain and encode at least one domain, such as the protease or extracellular domain, of the polypeptide. In particular, such nucleic acid molecules include any isolated nucleic fragment that encodes at least one domain of a membrane serine protease, that (1) contains a sequence of nucleotides that encodes the protease or a domain thereof, and (2) is selected from among:

(a) a sequence of nucleotides that encodes the protease or a domain thereof includes a sequence of nucleotides set forth above;

(b) a sequence of nucleotides that encodes such portion or the full length protease and hybridizes under conditions of high stringency, generally to nucleic acid that is complementary to a mRNA transcript present in a mammalian cell that encodes such protein or fragment thereof;

(c) a sequence of nucleotides that encodes a transmembrane protease or domain thereof that includes a sequence of amino acids encoded by such portion or the full length open reading frame; and

(d) a sequence of nucleotides that encodes the transmembrane protease that includes a sequence of amino acids encoded by a sequence of nucleotides that encodes such subunit and hybridizes under conditions of low, moderate or high stringency to DNA that is complementary to the mRNA transcript.

The isolated nucleic acids can include of at least 8 nucleotides of an MTSP7-encoding sequence. In other embodiments, the nucleic acids can contain least 25 (continuous) nucleotides, 50 nucleotides, 100 nucleotides, 150 nucleotides, or 200 nucleotides of an MTSP7-encoding sequence, or a full-length MTSP coding sequence. In another embodiment, the nucleic acids are smaller than 35, 200 or 500 nucleotides in length. Nucleic acids can be single or double stranded. Nucleic acids that hybridizes to or complementary to the foregoing sequences, in particular the inverse complement to nucleic acids that hybridizes to the foregoing sequences (*i.e.*, the inverse complement of a nucleic acid strand has the complementary sequence running in reverse orientation to the strand so that the inverse complement would hybridize without mismatches to the nucleic acid strand; thus, for example, where the coding strand hybridizes to a nucleic acid with no mismatches between the coding strand and the hybridizing strand, then the inverse

complement of the hybridizing strand is identical to the coding strand) are also provided.

In specific aspects, nucleic acids are provided that include a sequence complementary to (specifically are the inverse complement of) at least 10, 25, 50, 100, or 200 nucleotides or the entire coding region of an MTSP7 encoding nucleic acid, particularly the protease domain thereof. For MTSP7 the full-length protein or a domain or active fragment thereof is also provided.

For each of the nucleic acid molecules, the nucleic acid can be DNA or RNA or PNA or other nucleic acid analogs or can include non-natural nucleotide bases. Also provided are isolated nucleic acid molecules that include a sequence of nucleotides complementary to the nucleotide sequence encoding an MTSP.

Probes and primers derived from the nucleic acid molecules are provided, Such probes and primers contain at least 8, 14, 16, 30, 100 or more contiguous nucleotides with identity to contiguous nucleotides of an MTSP7, generally except for nucleic acids encoding 117-171 and 185-354 of SEQ ID No. 15. The probes and primers are optionally labelled with a detectable label, such as a radiolabel or a fluorescent tag, or can be mass differentiated for detection by mass spectrometry or other means.

Plasmids and Cells

Plasmids and vectors containing the nucleic acid molecules are also provided. Cells containing the vectors, including cells that express the encoded proteins are provided. The cell can be a bacterial cell, a yeast cell, a fungal cell, a plant cell, an insect cell or an animal cell. Methods for producing an MTSP or single chain form of the protease domain thereof by, for example, growing the cell under conditions whereby the encoded MTSP is expressed by the cell, and recovering the expressed protein, are provided herein. As noted, for MTSP7, the full-length

zymogens and activated proteins and activated (two chain) protease and single chain protease domains are provided. As described herein, the cells are used for expression of the protein, which can be secreted or expressed in the cytoplasm.

The above discussion provides an overview and some details of the exemplified MTSP7s. The following discussion provides additional details (see, also, EXAMPLES).

C. Tumor specificity and tissue expression profiles

Each MTSP has a characteristic tissue expression profile; the MTSPs in particular, although not exclusively expressed or activated in tumors, exhibit characteristic tumor tissue expression or activation profiles. In some instances, MTSPs can have different activity in a tumor cell from a non-tumor cell by virtue of a change in a substrate or cofactor therefor or other factor that would alter the apparent functional activity of the MTSP. Hence each can serve as a diagnostic marker for particular tumors, by virtue of a level of activity and/or expression or function in a subject (i.e. a mammal, particularly a human) with neoplastic disease, compared to a subject or subjects that do not have the neoplastic disease. In addition, detection of activity (and/or expression) in a particular tissue can be indicative of neoplastic disease. Shed MTSPs in body fluids can be indicative of neoplastic disease. Also, by virtue of the activity and/or expression profiles of each, they can serve as therapeutic targets, such as by administration of modulators of the activity thereof, or, as by administration of a prodrug specifically activated by one of the MTSPs.

Tissue expression profiles

MTSP7

The MTSP7 transcript was detected in lung carcinoma (A549 cell line), leukemia (K-562 cell line) and cervical carcinoma (HeLaS3 cell line).

D. Identification and isolation of MTSP protein genes

The MTSP proteins, or domains thereof, can be obtained by methods well known in the art for protein purification and recombinant protein expression. Any method known to those of skill in the art for identification of nucleic acids that encode desired genes can be used. Any method available in the art can be used to obtain a full length (*i.e.*, encompassing the entire coding region) cDNA or genomic DNA clone encoding an MTSP protein. In particular, the polymerase chain reaction (PCR) can be used to amplify a sequence identified as being differentially expressed in normal and tumor cells or tissues, *e.g.*, nucleic acids encoding an MTSP7 protein (SEQ. NOs: 15-17), in a genomic or cDNA library. Oligonucleotide primers that hybridize to sequences at the 3′ and 5′ termini of the identified sequences can be used as primers to amplify by PCR sequences from a nucleic acid sample (RNA or DNA), generally a cDNA library, from an appropriate source (*e.g.*, tumor or cancer tissue).

PCR can be carried out, *e.g.*, by use of a Perkin-Elmer Cetus thermal cycler and Taq polymerase (Gene Amp™). The DNA being amplified can include mRNA or cDNA or genomic DNA from any eukaryotic species. One can choose to synthesize several different degenerate primers, for use in the PCR reactions. It is also possible to vary the stringency of hybridization conditions used in priming the PCR reactions, to amplify nucleic acid homologs (*e.g.*, to obtain *MTSP protein* sequences from species other than humans or to obtain human sequences with homology to MTSP7 protein) by allowing for greater or lesser degrees of nucleotide sequence similarity between the known nucleotide sequence and the nucleic acid homolog being isolated. For cross species hybridization, low stringency to moderate conditions are used. For same species hybridization, moderately stringent to highly stringent conditions are used. The conditions can be empirically determined.

After successful amplification of the nucleic acid containing all or a portion of the identified MTSP protein sequence or of a nucleic acid

encoding all or a portion of an MTSP protein homolog, that segment can be molecularly cloned and sequenced, and used as a probe to isolate a complete cDNA or genomic clone. This, in turn, permits the determination of the gene's complete nucleotide sequence, the analysis of its expression, and the production of its protein product for functional analysis. Once the nucleotide sequence is determined, an open reading frame encoding the MTSP protein gene protein product can be determined by any method well known in the art for determining open reading frames, for example, using publicly available computer programs for nucleotide sequence analysis. Once an open reading frame is defined, it is routine to determine the amino acid sequence of the protein encoded by the open reading frame. In this way, the nucleotide sequences of the entire MTSP protein genes as well as the amino acid sequences of MTSP protein proteins and analogs can be identified.

Any eukaryotic cell potentially can serve as the nucleic acid source for the molecular cloning of the MTSP protein gene. The nucleic acids can be isolated from vertebrate, mammalian, human, porcine, bovine, feline, avian, equine, canine, as well as additional primate sources, insects, plants and other organisms. The DNA can be obtained by standard procedures known in the art from cloned DNA (*e.g.*, a DNA "library"), by chemical synthesis, by cDNA cloning, or by the cloning of genomic DNA, or fragments thereof, purified from the desired cell (see, *e.g.*, Sambrook *et al.* 1989, Molecular Cloning, A Laboratory Manual, 2d Ed., Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York; Glover, D.M. (ed.), 1985, DNA Cloning: A Practical Approach, MRL Press, Ltd., Oxford, U.K. Vol. I, II). Clones derived from genomic DNA can contain regulatory and intron DNA regions in addition to coding regions; clones derived from cDNA will contain only exon sequences. For any source, the gene is cloned into a suitable vector for propagation thereof.

In the molecular cloning of the gene from genomic DNA, DNA fragments are generated, some of which will encode the desired gene.

The DNA can be cleaved at specific sites using various restriction enzymes. Alternatively, one can use DNAse in the presence of manganese to fragment the DNA, or the DNA can be physically sheared, for example, by sonication. The linear DNA fragments then can be separated according to size by standard techniques, including but not limited to, agarose and polyacrylamide gel electrophoresis and column chromatography.

Once the DNA fragments are generated, identification of the specific DNA fragment containing the desired gene can be accomplished in a number of ways. For example, a portion of the MTSP protein (of any species) gene (*e.g.*, a PCR amplification product obtained as described above or an oligonucleotide having a sequence of a portion of the known nucleotide sequence) or its specific RNA, or a fragment thereof be purified and labeled, and the generated DNA fragments can be screened by nucleic acid hybridization to the labeled probe (Benton and Davis, *Science* 196:180 (1977); Grunstein and Hogness, *Proc. Natl. Acad. Sci. U.S.A.* 72:3961 (1975)). Those DNA fragments with substantial homology to the probe will hybridize. It is also possible to identify the appropriate fragment by restriction enzyme digestion(s) and comparison of fragment sizes with those expected according to a known restriction map if such is available or by DNA sequence analysis and comparison to the known nucleotide sequence of MTSP protein. Further selection can be carried out on the basis of the properties of the gene. Alternatively, the presence of the gene can be detected by assays based on the physical, chemical, or immunological properties of its expressed product. For example, cDNA clones, or DNA clones which hybrid-select the proper mRNA, can be selected which produce a protein that, *e.g.*, has similar or identical electrophoretic migration, isolectric focusing behavior, proteolytic digestion maps, antigenic properties, serine protease activity. If an anti-MTSP protein antibody is available, the protein can be identified by binding of labeled antibody to the putatively MTSP protein synthesizing

clones, in an ELISA (enzyme-linked immunosorbent assay)-type procedure.

Alternatives to isolating the MTSP7 protein genomic DNA include, but are not limited to, chemically synthesizing the gene sequence from a known sequence or making cDNA to the mRNA that encodes the MTSP protein. For example, RNA for cDNA cloning of the MTSP protein gene can be isolated from cells expressing the protein. The identified and isolated nucleic acids then can be inserted into an appropriate cloning vector. A large number of vector-host systems known in the art can be used. Possible vectors include, but are not limited to, plasmids or modified viruses, but the vector system must be compatible with the host cell used. Such vectors include, but are not limited to, bacteriophages such as lambda derivatives, or plasmids such as pBR322 or pUC plasmid derivatives or the Bluescript vector (Stratagene, La Jolla, CA). The insertion into a cloning vector can, for example, be accomplished by ligating the DNA fragment into a cloning vector which has complementary cohesive termini. If the complementary restriction sites used to fragment the DNA are not present in the cloning vector, the ends of the DNA molecules can be enzymatically modified. Alternatively, any site desired can be produced by ligating nucleotide sequences (linkers) onto the DNA termini; these ligated linkers can comprise specific chemically synthesized oligonucleotides encoding restriction endonuclease recognition sequences. In an alternative method, the cleaved vector and MTSP protein gene can be modified by homopolymeric tailing. Recombinant molecules can be introduced into host cells via transformation, transfection, infection, electroporation, calcium precipitation and other methods, so that many copies of the gene sequence are generated.

In an alternative method, the desired gene can be identified and isolated after insertion into a suitable cloning vector in a "shot gun" approach. Enrichment for the desired gene, for example, by size fractionization, can be done before insertion into the cloning vector.

In specific embodiments, transformation of host cells with recombinant DNA molecules that incorporate the isolated MTSP protein gene, cDNA, or synthesized DNA sequence enables generation of multiple copies of the gene. Thus, the gene can be obtained in large quantities by growing transformants, isolating the recombinant DNA molecules from the transformants and, when necessary, retrieving the inserted gene from the isolated recombinant DNA.

E. Vectors, plasmids and cells that contain nucleic acids encoding an MTSP protein or protease domain thereof and expression of MTSP proteins

Vectors and cells

For recombinant expression of one or more of the MTSP proteins, the nucleic acid containing all or a portion of the nucleotide sequence encoding the MTSP protein can be inserted into an appropriate expression vector, *i.e.*, a vector that contains the necessary elements for the transcription and translation of the inserted protein coding sequence. The necessary transcriptional and translational signals can also be supplied by the native promoter for MTSP genes, and/or their flanking regions.

Also provided are vectors that contain nucleic acid encoding the MTSPs. Cells containing the vectors are also provided. The cells include eukaryotic and prokaryotic cells, and the vectors are any suitable for use therein.

Prokaryotic and eukaryotic cells, including endothelial cells, containing the vectors are provided. Such cells include bacterial cells, yeast cells, fungal cells. plant cells, insect cells and animal cells. The cells are used to produce an MTSP protein or protease domain thereof by growing the above-described cells under conditions whereby the encoded MTSP protein or protease domain of the MTSP protein is expressed by the cell, and recovering the expressed protease domain protein. In the exemplified embodiments, the protease domain is secreted into the medium.

In one embodiment, the vectors include a sequence of nucleotides that encodes a polypeptide that has protease activity and contains all or a portion of only the protease domain, or multiple copies thereof, of an MTSP protein are provided. Also provided are vectors that comprise a sequence of nucleotides that encodes the protease domain and additional portions of an MTSP protein up to and including a full length MTSP protein, as well as multiple copies thereof, are also provided. The vectors can selected for expression of the MTSP protein or protease domain thereof in the cell or such that the MTSP protein is expressed as a transmembrane protein. Alternatively, the vectors can include signals necessary for secretion of encoded proteins. When the protease domain is expressed the nucleic acid can be linked to a nucleic acid sequence encoding a secretion signal, such as the *Saccharomyces cerevisiae a* mating factor signal sequence or a portion thereof sufficient for secretion. Any such signal sequence can be used.

A variety of host-vector systems can be used to express the protein coding sequence. These include but are not limited to mammalian cell systems infected with virus (*e.g.* vaccinia virus, adenovirus, herpes virus, and other virus-derived vectors); insect cell systems infected with virus (*e.g.* baculovirus); microorganisms such as yeast containing yeast vectors; or bacteria transformed with bacteriophage, DNA, plasmid DNA, or cosmid DNA. The expression elements of vectors vary in their strengths and specificities. Depending on the host-vector system used, any one of a number of suitable transcription and translation elements can be used.

Any methods known to those of skill in the art for the insertion of DNA fragments into a vector can be used to construct expression vectors containing a chimeric gene containing of appropriate transcriptional/translational control signals and protein coding sequences. These methods can include *in vitro* recombinant DNA and synthetic techniques and *in vivo* recombinants (genetic recombination). Expression

of nucleic acid sequences encoding MTSP protein, or domains, derivatives, fragments or homologs thereof, can be regulated by a second nucleic acid sequence so that the genes or fragments thereof are expressed in a host transformed with the recombinant DNA molecule(s). For example, expression of the proteins can be controlled by any promoter/enhancer known in the art. In a specific embodiment, the promoter is not native to the genes for MTSP protein. Promoters which can be used include but are not limited to the SV40 early promoter (Bernoist and Chambon, *Nature* 290:304-310 (1981)), the promoter contained in the 3' long terminal repeat of Rous sarcoma virus (Yamamoto et al., *Cell* 22:787-797 (1980)), the herpes thymidine kinase promoter (Wagner et al., *Proc. Natl. Acad. Sci. USA* 78:1441-1445 (1981)), the regulatory sequences of the metallothionein gene (Brinster et al., *Nature* 296:39-42 (1982)); prokaryotic expression vectors such as the β-lactamase promoter (Villa-Kamaroff et al., *Proc. Natl. Acad. Sci. USA* 75:3727-3731 1978)) or the *tac* promoter (DeBoer et al., *Proc. Natl. Acad. Sci. USA* 80:21-25 (1983)); see also "Useful Proteins from Recombinant Bacteria": in Scientific American 242:79-94 (1980)); plant expression vectors containing the nopaline synthetase promoter (Herrar-Estrella et al., *Nature* 303:209-213 (1984)) or the cauliflower mosaic virus 35S RNA promoter (Garder et al., *Nucleic Acids Res.* 9:2871 (1981)), and the promoter of the photosynthetic enzyme ribulose bisphosphate carboxylase (Herrera-Estrella et al., *Nature* 310:115-120 (1984)); promoter elements from yeast and other fungi such as the Gal4 promoter, the alcohol dehydrogenase promoter, the phosphoglycerol kinase promoter, the alkaline phosphatase promoter, and the following animal transcriptional control regions that exhibit tissue specificity and have been used in transgenic animals: elastase I gene control region which is active in pancreatic acinar cells (Swift et al., *Cell* 38:639-646 (1984); Ornitz et al., *Cold Spring Harbor Symp. Quant. Biol.* 50:399-409 (1986); MacDonald, *Hepatology* 7:425-515 (1987)); insulin gene control

region which is active in pancreatic beta cells (Hanahan et al., *Nature* 315:115-122 (1985)), immunoglobulin gene control region which is active in lymphoid cells (Grosschedl et al., *Cell* 38:647-658 (1984); Adams et al., *Nature* 318:533-538 (1985); Alexander et al., *Mol. Cell Biol.* 7:1436-1444 (1987)), mouse mammary tumor virus control region which is active in testicular, breast, lymphoid and mast cells (Leder et al., *Cell* 45:485-495 (1986)), albumin gene control region which is active in liver (Pinckert et al., *Genes and Devel.* 1:268-276 (1987)), alpha-fetoprotein gene control region which is active in liver (Krumlauf et al., *Mol. Cell. Biol.* 5:1639-1648 (1985); Hammer et al., *Science* 235:53-58 1987)), alpha-1 antitrypsin gene control region which is active in liver (Kelsey et al., *Genes and Devel.* 1:161-171 (1987)), beta globin gene control region which is active in myeloid cells (Mogram et al., *Nature* 315:338-340 (1985); Kollias et al., *Cell* 46:89-94 (1986)), myelin basic protein gene control region which is active in oligodendrocyte cells of the brain (Readhead et al., *Cell* 48:703-712 (1987)), myosin light chain-2 gene control region which is active in skeletal muscle (Sani, *Nature* 314:283-286 (1985)), and gonadotrophic releasing hormone gene control region which is active in gonadotrophs of the hypothalamus (Mason et al., *Science* 234:1372-1378 (1986)).

In a specific embodiment, a vector is used that contains a promoter operably linked to nucleic acids encoding an MTSP protein, or a domain, fragment, derivative or homolog, thereof, one or more origins of replication, and optionally, one or more selectable markers (*e.g.*, an antibiotic resistance gene). Expression vectors containing the coding sequences, or portions thereof, of an MTSP protein, is made, for example, by subcloning the coding portions into the EcoRI restriction site of each of the three pGEX vectors (glutathione S-transferase expression vectors (Smith and Johnson, *Gene* 7:31-40 (1988)). This allows for the expression of products in the correct reading frame. Exemplary vectors and systems for expression of the protease domains of the MTSP proteins

include the well-known *Pichia* vectors (available, for example, from Invitrogen, San Diego, CA), particularly those designed for secretion of the encoded proteins. The protein can also be expressed cytoplasmically, such as in the inclusion bodies. One exemplary vector is described in the EXAMPLES.

Plasmids for transformation of *E. coli* cells, include, for example, the pET expression vectors (see, U.S patent 4,952,496; available from NOVAGEN, Madison, WI; see, also literature published by Novagen describing the system). Such plasmids include pET 11a, which contains the T7lac promoter, T7 terminator, the inducible *E. coli* lac operator, and the lac repressor gene; pET 12a-c, which contains the T7 promoter, T7 terminator, and the *E. coli* ompT secretion signal; and pET 15b and pET19b (NOVAGEN, Madison, WI), which contain a His-Tag™ leader sequence for use in purification with a His column and a thrombin cleavage site that permits cleavage following purification over the column; the T7-lac promoter region and the T7 terminator.

The vectors are introduced into host cells, such as *Pichia* cells and bacterial cells, such as *E. coli*, and the proteins expressed therein. Exemplary *Pichia* strains, include, for example, GS115. Exemplary bacterial hosts contain chromosomal copies of DNA encoding T7 RNA polymerase operably linked to an inducible promoter, such as the lacUV promoter (see, U.S. Patent No. 4,952,496). Such hosts include, but are not limited to, the lysogenic *E. coli* strain BL21(DE3).

Expression and production of proteins

The MTSP domains, derivatives and analogs be produced by various methods known in the art. For example, once a recombinant cell expressing an MTSP protein, or a domain, fragment or derivative thereof, is identified, the individual gene product can be isolated and analyzed. This is achieved by assays based on the physical and/or functional properties of the protein, including, but not limited to, radioactive labeling of the product followed by analysis by gel electrophoresis, immunoassay,

cross-linking to marker-labeled product. The MTSP proteins can be isolated and purified by standard methods known in the art (either from natural sources or recombinant host cells expressing the complexes or proteins), including but not restricted to column chromatography (*e.g.*, ion exchange, affinity, gel exclusion, reversed-phase high pressure and fast protein liquid), differential centrifugation, differential solubility, or by any other standard technique used for the purification of proteins. Functional properties can be evaluated using any suitable assay known in the art.

Alternatively, once an MTSP protein or its domain or derivative is identified, the amino acid sequence of the protein can be deduced from the nucleotide sequence of the gene which encodes it. As a result, the protein or its domain or derivative can be synthesized by standard chemical methods known in the art (*e.g.* see Hunkapiller et al, *Nature* 310:105-111 (1984)).

Manipulations of MTSP protein sequences can be made at the protein level. Also contemplated herein are MTSP protein proteins, domains thereof, derivatives or analogs or fragments thereof, which are differentially modified during or after translation, *e.g.*, by glycosylation, acetylation, phosphorylation, amidation, derivatization by known protecting/blocking groups, proteolytic cleavage, linkage to an antibody molecule or other cellular ligand. Any of numerous chemical modifications can be carried out by known techniques, including but not limited to specific chemical cleavage by cyanogen bromide, trypsin, chymotrypsin, papain, V8 protease, $NaBH_4$, acetylation, formylation, oxidation, reduction, metabolic synthesis in the presence of tunicamycin and other such agents.

In addition, domains, analogs and derivatives of an MTSP protein can be chemically synthesized. For example, a peptide corresponding to a portion of an MTSP protein, which includes the desired domain or which mediates the desired activity *in vitro* can be synthesized by use of a peptide synthesizer. Furthermore, if desired, nonclassical amino acids or

chemical amino acid analogs can be introduced as a substitution or addition into the MTSP protein sequence. Non-classical amino acids include but are not limited to the D-isomers of the common amino acids, a-amino isobutyric acid, 4-aminobutyric acid, Abu, 2-aminobutyric acid, ϵ-Abu, e-Ahx, 6-amino hexanoic acid, Aib, 2-amino isobutyric acid, 3-amino propionoic acid, ornithine, norleucine, norvaline, hydroxyproline, sarcosine, citrulline, cysteic acid, t-butylglycine, t-butylalanine, phenylglycine, cyclohexylalanine, ß-alanine, fluoro-amino acids, designer amino acids such as ß-methyl amino acids, Ca-methyl amino acids, Na-methyl amino acids, and amino acid analogs in general. Furthermore, the amino acid can be D (dextrorotary) or L (levorotary).

In cases where natural products are suspected of being mutant or are isolated from new species, the amino acid sequence of the MTSP protein isolated from the natural source, as well as those expressed *in vitro*, or from synthesized expression vectors *in vivo* or *in vitro*, can be determined from analysis of the DNA sequence, or alternatively, by direct sequencing of the isolated protein. Such analysis can be performed by manual sequencing or through use of an automated amino acid sequenator.

Modifications

A variety of modification of the MTSP proteins and domains are contemplated herein. An MTSP-encoding nucleic acid molecule be modified by any of numerous strategies known in the art (Sambrook et al., 1990, *Molecular Cloning, A Laboratory Manual*, 2d ed., Cold Spring Harbor Laboratory, Cold Spring Harbor, New York). The sequences can be cleaved at appropriate sites with restriction endonuclease(s), followed by further enzymatic modification if desired, isolated, and ligated *in vitro*. In the production of the gene encoding a domain, derivative or analog of MTSP, care should be taken to ensure that the modified gene retains the original translational reading frame, uninterrupted by translational stop signals, in the gene region where the desired activity is encoded.

Additionally, the MTSP-encoding nucleic acid molecules can be mutated *in vitro* or *in vivo*, to create and/or destroy translation, initiation, and/or termination sequences, or to create variations in coding regions and/or form new restriction endonuclease sites or destroy pre-existing ones, to facilitate further *in vitro* modification. Also, as described herein muteins with primary sequence alterations, such as replacements of Cys residues and elimination or addition of glycosylation sites are contemplated; the MTSP7 of SEQ ID No. 16 has no potential glycosylation sites. Such mutations can be effected by any technique for mutagenesis known in the art, including, but not limited to, chemical mutagenesis and *in vitro* site-directed mutagenesis (Hutchinson et al., *J. Biol. Chem.* 253:6551-6558 (1978)), use of TAB® linkers (Pharmacia). In one embodiment, for example, an MTSP protein or domain thereof is modified to include a fluorescent label. In other specific embodiments, the MTSP protein is modified to have a heterobifunctional reagent, such heterobifunctional reagents can be used to crosslink the members of the complex.

The MTSP proteins can be isolated and purified by standard methods known in the art (either from natural sources or recombinant host cells expressing the complexes or proteins), including but not restricted to column chromatography (*e.g.*, ion exchange, affinity, gel exclusion, reversed-phase high pressure and fast protein liquid), differential centrifugation, differential solubility, or by any other standard technique used for the purification of proteins. Functional properties can be evaluated using any suitable assay known in the art.

Alternatively, once a MTSP or its domain or derivative is identified, the amino acid sequence of the protein can be deduced from the nucleotide sequence of the gene which encodes it. As a result, the protein or its domain or derivative can be synthesized by standard chemical methods known in the art (*e.g.*, see Hunkapiller et al, *Nature*, 310:105-111 (1984)).

Manipulations of MTSP sequences can be made at the protein level. MTSP domains, derivatives or analogs or fragments, which are differentially modified during or after translation, *e.g.*, by glycosylation, acetylation, phosphorylation, amidation, derivatization by known protecting/blocking groups, proteolytic cleavage, linkage to an antibody molecule and other cellular ligand, are contemplated herein. Any of numerous chemical modifications can be carried out by known techniques, including but not limited to specific chemical cleavage by cyanogen bromide, trypsin, chymotrypsin, papain, V8 protease, $NaBH_4$, acetylation, formylation, oxidation, reduction, metabolic synthesis in the presence of tunicamycin.

In addition, domains, analogs and derivatives of a MTSP can be chemically synthesized. For example, a peptide corresponding to a portion of a MTSP, which comprises the desired domain or which mediates the desired activity *in vitro* can be synthesized by use of a peptide synthesizer. Furthermore, if desired, nonclassical amino acids or chemical amino acid analogs can be introduced as a substitution or addition into the MTSP sequence. Non-classical amino acids include but are not limited to the D-isomers of the common amino acids, a-amino isobutyric acid, 4-aminobutyric acid, Abu, 2-aminobutyric acid, ϵ-Abu, e-Ahx, 6-amino hexanoic acid, Aib, 2-amino isobutyric acid, 3-amino propionoic acid, ornithine, norleucine, norvaline, hydroxyproline, sarcosine, citrulline, cysteic acid, t-butylglycine, t-butylalanine, phenylglycine, cyclohexylalanine, ß-alanine, fluoro-amino acids, designer amino acids such as ß-methyl amino acids, Ca-methyl amino acids, Na-methyl amino acids, and amino acid analogs in general. Furthermore, the amino acid can be D (dextrorotary) or L (levorotary).

F. SCREENING METHODS

The single chain protease domains, as shown herein, can be used in a variety of methods to identify compounds that modulate the activity thereof. For MTSPs that exhibit higher activity or expression in tumor

cells, compounds that inhibit the proteolytic activity are of particular interest. For any MTSPs that are active at lower levels in tumor cells, compounds or agents that enhance the activity are potentially of interest. In all instances the identified compounds will include agents that are candidate cancer treatments.

Several types of assays are exemplified and described herein. It is understood that the protease domains can be used in other assays. It is shown here, however, that the single chain protease domains exhibit catalytic activity. As such they are ideal for *in vitro* screening assays. They can also be used in binding assays.

The MTSP7 full length zymogens, activated enzymes, single and two chain protease domains are contemplated for use in any screening assay known to those of skill in the art, including those provided herein. Hence the following description, if directed to proteolytic assays is intended to apply to use of a single chain protease domain or a catalytically active portion thereof of any MTSP, including an MTSP7. Other assays, such as binding assays are provided herein, particularly for use with an MTSP7, including any variants, such as splice variants thereof.

1. Catalytic Assays for identification of agents that modulate the protease activity of an MTSP protein

Methods for identifying a modulator of the catalytic activity of an MTSP, particularly a single chain protease domain or catalytically active portion thereof, are provided herein. The methods can be practiced by: a) contacting the MTSP7, a full-length zymogen or activated form, and particularly a single-chain domain thereof, with a substrate of the MTSP7 in the presence of a test substance, and detecting the proteolysis of the substrate, whereby the activity of the MTSP7 is assessed, and comparing the activity to a control. For example, the control can be the activity of the MTSP7 assessed by contacting an MTSP7, including a full-length zymogen or activated form, and particularly a single-chain domain thereof,

particularly a single-chain domain thereof, with a substrate of the MTSP7, and detecting the proteolysis of the substrate, whereby the activity of the MTSP7 is assessed. The results in the presence and absence of the test compounds are compared. A difference in the activity indicates that the test substance modulates the activity of the MTSP7.

In one embodiment a plurality of the test substances are screened simultaneously in the above screening method. In another embodiment, the MTSP7 is isolated from a target cell as a means for then identifying agents that are potentially specific for the target cell.

In still another embodiment, The test substance is a therapeutic compound, and whereby a difference of the MTSP7 activity measured in the presence and in the absence of the test substance indicates that the target cell responds to the therapeutic compound.

One method include the steps of (a) contacting the MTSP7 protein or protease domain thereof with one or a plurality of test compounds under conditions conducive to interaction between the ligand and the compounds; and (b) identifying one or more compounds in the plurality that specifically binds to the ligand.

Another method provided herein includes the steps of a) contacting an MTSP7 protein or protease domain thereof with a substrate of the MTSP7 protein, and detecting the proteolysis of the substrate, whereby the activity of the MTSP7 protein is assessed; b) contacting the MTSP7 protein with a substrate of the MTSP7 protein in the presence of a test substance, and detecting the proteolysis of the substrate, whereby the activity of the MTSP7 protein is assessed; and c) comparing the activity of the MTSP7 protein assessed in steps a) and b), whereby the activity measured in step a) differs from the activity measured in step b) indicates that the test substance modulates the activity of the MTSP7 protein.

In another embodiment, a plurality of the test substances are screened simultaneously. In comparing the activity of an MTSP7 protein in the presence and absence of a test substance to assess whether the

test substance is a modulator of the MTSP7 protein, it is unnecessary to assay the activity in parallel, although such parallel measurement is typically employed. It is possible to measure the activity of the MTSP7 protein at one time point and compare the measured activity to a historical value of the activity of the MTSP7 protein.

For instance, one can measure the activity of the MTSP7 protein in the presence of a test substance and compare with historical value of the activity of the MTSP7 protein measured previously in the absence of the test substance, and *vice versa*. This can be accomplished, for example, by providing the activity of the MTSP7 protein on an insert or pamphlet provided with a kit for conducting the assay.

Methods for selecting substrates for a particular MTSP are described in the EXAMPLES, and particular proteolytic assays are exemplified.

Combinations and kits containing the combinations optionally including instructions for performing the assays are provided. The combinations include an MTSP7 protein and a substrate of the MTSP7 protein to be assayed; and, optionally reagents for detecting proteolysis of the substrate. The substrates, which are typically proteins subject to proteolysis by a particular MTSP7 protein, can be identified empirically by testing the ability of the MTSP7 protein to cleave the test substrate. Substrates that are cleaved most effectively (i.e., at the lowest concentrations and/or fastest rate or under desirable conditions), are identified.

Additionally provided herein is a kit containing the above-described combination. The kit optionally further includes instructions for identifying a modulator of the activity of an MTSP7 protein. Any MTSP7 protein is contemplated as target for identifying modulators of the activity thereof.

2. **Binding assays**

Also provided herein are methods for identification and isolation of agents, particularly compounds that bind to MTSP7s. The assays are designed to identify agents that bind to the zymogen form, the single chain isolated protease domain (or a protein, other than an MTSP7 protein, that contains the protease domain of an MTSP7 protein), and to the activated form, including the activated form derived from the full length zymogen or from an extended protease domain. The identified compounds are candidates or leads for identification of compounds for treatments of tumors and other disorders and diseases involving aberrant angiogenesis. The MTSP7 proteins used in the methods include any MTSP7 protein as defined herein, and generally use MTSP7 single chain domain or proteolytically active portion thereof.

A variety of methods are provided herein. These methods can be performed in solution or in solid phase reactions in which the MTSP7 protein(s) or protease domain(s) thereof are linked, either directly or indirectly via a linker, to a solid support. Screening assays are described in the Examples, and these assays have been used to identify candidate compounds. For purposes herein, all binding assays described above are provided for MTSP7.

Methods for identifying an agent, such as a compound, that specifically binds to an MTSP7 single chain protease domain, a zymogen or full-length activated MTSP7 or two chain protease domain thereof are provided herein. The method can be practiced by (a) contacting the MTSP7 with one or a plurality of test agents under conditions conducive to binding between the MTSP7 and an agent; and (b) identifying one or more agents within the plurality that specifically binds to the MTSP7.

For example, in practicing such methods the MTSP7 polypeptide is mixed with a potential binding partner or an extract or fraction of a cell under conditions that allow the association of potential binding partners with the polypeptide. After mixing, peptides, polypeptides, proteins or

other molecules that have become associated with an MTSP7 are separated from the mixture. The binding partner that bound to the MTSP7 then can be removed and further analyzed. To identify and isolate a binding partner, the entire protein, for instance the entire disclosed protein of SEQ ID Nos. 15 or 17 can be used. Alternatively, a fragment of the protein can be used.

A variety of methods can be used to obtain cell extracts. Cells can be disrupted using either physical or chemical disruption methods. Examples of physical disruption methods include, but are not limited to, sonication and mechanical shearing. Examples of chemical lysis methods include, but are not limited to, detergent lysis and enzyme lysis. A skilled artisan can readily adapt methods for preparing cellular extracts in order to obtain extracts for use in the present methods.

Once an extract of a cell is prepared, the extract is mixed with the MTSP7 under conditions in which association of the protein with the binding partner can occur. A variety of conditions can be used. Exemplary conditions are those that closely resemble conditions found in the cytoplasm of a human cell. Features such as osmolarity, pH, temperature, and the concentration of cellular extract used, can be varied to optimize the association of the protein with the binding partner.

After mixing under appropriate conditions, the bound complex is separated from the mixture. A variety of techniques can be used to separate the mixture. For example, antibodies specific to an MTSP7 can be used to immunoprecipitate the binding partner complex. Alternatively, standard chemical separation techniques such as chromatography and density/sediment centrifugation can be used.

After removing the non-associated cellular constituents in the extract, the binding partner can be dissociated from the complex using conventional methods. For example, dissociation can be accomplished by altering the salt concentration or pH of the mixture.

To aid in separating associated binding partner pairs from the mixed extract, the MTSP7 can be immobilized on a solid support. For example, the protein can be attached to a nitrocellulose matrix or acrylic beads. Attachment of the protein or a fragment thereof to a solid support aids in separating peptide/binding partner pairs from other constituents found in the extract. The identified binding partners can be either a single protein or a complex made up of two or more proteins.

Alternatively, the nucleic acid molecules encoding the single chain proteases can be used in a yeast two-hybrid system. The yeast two-hybrid system has been used to identify other protein partner pairs and can readily be adapted to employ the nucleic acid molecules herein described.

Another *in vitro* binding assay, particularly for an MTSP7, uses a mixture of a polypeptide that contains at least the catalytic domain of one of these proteins and one or more candidate binding targets or substrates. After incubating the mixture under appropriate conditions, the ability of the MTSP7 or a polypeptide fragment thereof containing the catalytic domain to bind to or interact with the candidate substrate is assessed. For cell-free binding assays, one of the components includes or is coupled to a detectable label. The label can provide for direct detection, such as radioactivity, luminescence, optical or electron density, or indirect detection such as an epitope tag, an enzyme and other such agents. A variety of methods can be employed to detect the label depending on the nature of the label and other assay components. For example, the label can be detected bound to the solid substrate or a portion of the bound complex containing the label can be separated from the solid substrate, and the label thereafter detected.

3. Detection of signal transduction

The cell surface location of the MTSPs suggests a role for some or all of these proteins in signal transduction. Assays for assessing signal transduction are well known to those of skill in the art, and can be adapted for use with the MTSP7 protein.

Assays for identifying agents that effect or alter signal transduction mediated directly or indirectly, such as via activation of a pro-growth factor, by an MTSP7, particularly the full length or a sufficient portion to anchor the extracellular domain or a function portion thereof of an MTSP on the surface of a cell are provided. Such assays, include, for example, transcription based assays in which modulation of a transduced signal is assessed by detecting an effect on an expression from a reporter gene (see, *e.g.*, U.S. Patent No. 5,436,128).

4. Methods for Identifying Agents that Modulate the Expression a Nucleic Acid Encoding an MTSP7

Another embodiment provides methods for identifying agents that modulate the expression of a nucleic acid encoding an MTSP7. Such assays use any available means of monitoring for changes in the expression level of the nucleic acids encoding an MTSP7.

In one assay format, cell lines that contain reporter gene fusions between the open reading frame of MTSP7 or a domain thereof, particularly the protease domain and any assayable fusion partner can be prepared. Numerous assayable fusion partners are known and readily available including the firefly luciferase gene and the gene encoding chloramphenicol acetyltransferase (Alam *et al., Anal. Biochem.* 188: 245-54 (1990)). Cell lines containing the reporter gene fusions are then exposed to the agent to be tested under appropriate conditions and time. Differential expression of the reporter gene between samples exposed to the agent and control samples identifies agents which modulate the expression of a nucleic acid encoding an MTSP7.

Additional assay formats can be used to monitor the ability of the agent to modulate the expression of a nucleic acid encoding an MTSP7. For instance, mRNA expression can be monitored directly by hybridization to the nucleic acids. Cell lines are exposed to the agent to be tested under appropriate conditions and time and total RNA or mRNA is isolated by standard procedures (see, *e.g.*, Sambrook *et al.* (1989) MOLECULAR CLONING: A LABORATORY MANUAL, 2nd Ed. Cold Spring Harbor Laboratory Press). Probes to detect differences in RNA expression levels between cells exposed to the agent and control cells can be prepared from the nucleic acids. Generally, although not necessarily, probes are designed to hybridize only with target nucleic acids under conditions of high stringency. Only highly complementary nucleic acid hybrids form under conditions of high stringency. Stringency should be chosen to maximize the difference in stability between the probe:target hybrid and potential probe:non-target hybrids.

Probes can be designed from the nucleic acids through methods known in the art. For instance, the G+C content of the probe and the probe length can affect probe binding to its target sequence. Methods to optimize probe specificity are commonly available (see, *e.g.*, Sambrook *et al.* (1989) MOLECULAR CLONING: A LABORATORY MANUAL, 2nd Ed. Cold Spring Harbor Laboratory Press); and Ausubel *et al.* (1995) CURRENT PROTOCOLS IN MOLECULAR BIOLOGY, Greene Publishing Co., NY).

Hybridization conditions are modified using known methods (see, *e.g.*, Sambrook *et al.* (1989) MOLECULAR CLONING: A LABORATORY MANUAL, 2nd Ed. Cold Spring Harbor Laboratory Press); and Ausubel *et al.* (1995) CURRENT PROTOCOLS IN MOLECULAR BIOLOGY, Greene Publishing Co., NY), as required for each probe. Hybridization of total cellular RNA or RNA enriched for polyA RNA can be accomplished in any available format. For instance, total cellular RNA or RNA enriched for polyA RNA can be affixed to a solid support, and the solid support

exposed to at least one probe comprising at least one, or part of one of the nucleic acid molecules under conditions in which the probe will specifically hybridize. Alternatively, nucleic acid fragments comprising at least one, or part of one of the sequences can be affixed to a solid support, such as a porous glass wafer. The glass wafer then can be exposed to total cellular RNA or polyA RNA from a sample under conditions in which the affixed sequences will specifically hybridize. Such glass wafers and hybridization methods are widely available, for example, those disclosed by Beattie (WO 95/11755). By examining for the ability of a given probe to specifically hybridize to an RNA sample from an untreated cell population and from a cell population exposed to the agent, agents which up or down regulate the expression of a nucleic acid encoding the protein having the sequence set forth in any of SEQ ID Nos. 15-18, particularly 18, are identified.

5. Methods for Identifying Agents that Modulate at Least One Activity of an MTSP7

Methods for identifying agents that modulate at least one activity of an MTSP7 are provided. Such methods or assays can use any means of monitoring or detecting the desired activity. In one format, the relative amounts of a protein between a cell population that has been exposed to the agent to be tested compared to an un-exposed control cell population can be assayed (*e.g.*, a prostate cancer cell line, a lung cancer cell line, a colon cancer cell line or a breast cancer cell line). In this format, probes, such as specific antibodies, are used to monitor the differential expression of the protein in the different cell populations. Cell lines or populations are exposed to the agent to be tested under appropriate conditions and time. Cellular lysates can be prepared from the exposed cell line or population and a control, unexposed cell line or population. The cellular lysates are then analyzed with the probe.

For example, N- and C- terminal fragments of the MTSP7 can be expressed in bacteria and used to search for proteins which bind to these

fragments. Fusion proteins, such as His-tag or GST fusion to the N- or C-terminal regions of the MTSP7 can be prepared for use as a substrate. These fusion proteins can be coupled to, for example, Glutathione-Sepharose beads and then probed with cell lysates. Prior to lysis, the cells can be treated with a candidate agent which can modulate an MTSP7 or proteins that interact with domains thereon. Lysate proteins binding to the fusion proteins can be resolved by SDS-PAGE, isolated and identified by protein sequencing or mass spectroscopy, as is known in the art.

Antibody probes are prepared by immunizing suitable mammalian hosts in appropriate immunization protocols using the peptides, polypeptides or proteins if they are of sufficient length (*e.g.*, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 20, 25, 30, 35, 40 or more consecutive amino acids the MTSP7 protein or if required to enhance immunogenicity, conjugated to suitable carriers. Methods for preparing immunogenic conjugates with carriers, such as bovine serum albumin (BSA), keyhole limpet hemocyanin (KLH), or other carrier proteins are well known in the art. In some circumstances, direct conjugation using, for example, carbodiimide reagents can be effective; in other instances linking reagents such as those supplied by Pierce Chemical Co., Rockford, IL, can be desirable to provide accessibility to the hapten. Hapten peptides can be extended at either the amino or carboxy terminus with a Cys residue or interspersed with cysteine residues, for example, to facilitate linking to a carrier. Administration of the immunogens is conducted generally by injection over a suitable time period and with use of suitable adjuvants, as is generally understood in the art. During the immunization schedule, titers of antibodies are taken to determine adequacy of antibody formation.

Anti-peptide antibodies can be generated using synthetic peptides corresponding to, for example, the carboxy terminal amino acids of the MTSP7. Synthetic peptides can be as small as 1-3 amino acids in length,

but are generally at least 4 or more amino acid residues long. The peptides can be coupled to KLH using standard methods and can be immunized into animals, such as rabbits or ungulate. Polyclonal antibodies then can be purified, for example using Actigel beads containing the covalently bound peptide.

While the polyclonal antisera produced in this way can be satisfactory for some applications, for pharmaceutical compositions, generally monoclonal preparations are used. Immortalized cell lines which secrete the desired monoclonal antibodies can be prepared using the standard method of Kohler *et al.*, (*Nature* 256: 495-7 (1975)) or modifications which effect immortalization of lymphocytes or spleen cells, as is generally known. The immortalized cell lines secreting the desired antibodies are screened by immunoassay in which the antigen is the peptide hapten, polypeptide or protein. When the appropriate immortalized cell culture secreting the desired antibody is identified, the cells can be cultured either *in vitro* or by production *in vivo* via ascites fluid. Of particular interest, are monoclonal antibodies that recognize the catalytic domain of the an MTSP7.

Additionally, the zymogen or two-chain forms the MTSP7 can be used to make monoclonal antibodies which recognize conformation epitopes. The desired monoclonal antibodies are then recovered from the culture supernatant or from the ascites supernatant. Fragments of the monoclonals or the polyclonal antisera which contain the immunologically significant portion can be used as antagonists, as well as the intact antibodies. Use of immunologically reactive fragments, such as the Fab, Fab', of $F(ab')_2$ fragments are often used, especially in a therapeutic context, as these fragments are generally less immunogenic than the whole immunoglobulin.

The antibodies or fragments can also be produced. Regions that bind specifically to the desired regions of receptor can also be produced in the context of chimeras with multiple species origin.

Agents that are assayed in the above method can be randomly selected or rationally selected or designed.

The agents can be, as examples, peptides, small molecules, and carbohydrates. A skilled artisan can readily recognize that there is no limit as to the structural nature of the agents.

The peptide agents can be prepared using standard solid phase (or solution phase) peptide synthesis methods, as is known in the art. In addition, the DNA encoding these peptides can be synthesized using commercially available oligonucleotide synthesis instrumentation and produced recombinantly using standard recombinant production systems. The production using solid phase peptide synthesis is necessitated if non-gene-encoded amino acids are to be included.

G. Assay formats and selection of test substances

A variety of formats and detection protocols are known for performing screening assays. Any such formats and protocols can be adapted for identifying modulators of MTSP7 protein activities. The following includes a discussion of exemplary protocols.

1. High throughput screening assays

Although the above-described assay can be conducted where a single MTSP7 protein is screened, and/or a single test substance is screened in one assay, the assay is generally conducted in a high throughput screening mode, *i.e.*, a plurality of the MTSP proteins are screened against and/or a plurality of the test substances are screened simultaneously (*See generally, High Throughput Screening: The Discovery of Bioactive Substances* (Devlin, Ed.) Marcel Dekker, 1997; Sittampalam et al., *Curr. Opin. Chem. Biol.*, 1(3):384-91 (1997); and Silverman et al., *Curr. Opin. Chem. Biol.*, 2(3):397-403 (1998)). For example, the assay can be conducted in a multi-well (*e.g.*, 24-, 48-, 96-, or 384-well), chip or array format.

High-throughput screening (HTS) is the process of testing a large number of diverse chemical structures against disease targets to identify

"hits" (Sittampalam et al., *Curr. Opin. Chem. Biol.*, 1(3):384-91 (1997)). Current state-of-the-art HTS operations are highly automated and computerized to handle sample preparation, assay procedures and the subsequent processing of large volumes of data.

Detection technologies employed in high-throughput screens depend on the type of biochemical pathway being investigated (Sittampalam et al., *Curr. Opin. Chem. Biol.*, 1(3):384-91 (1997)). These methods include, radiochemical methods, such as the scintillation proximity assays (SPA), which can be adapted to a variety of enzyme assays (Lerner et al., *J. Biomol. Screening*, 1:135-143 (1996); Baker et al., *Anal. Biochem.*, 239:20-24 (1996); Baum et al., *Anal. Biochem.*, 237:129-134 (1996); and Sullivan et al., *J. Biomol. Screening*, 2:19-23 (1997)) and protein-protein interaction assays (Braunwalder et al., *J. Biomol. Screening*, 1:23-26 (1996); Sonatore et al., *Anal. Biochem.*, 240:289-297 (1996); and Chen et al., *J. Biol. Chem.*, 271:25308-25315 (1996)), and non-isotopic detection methods, including but are not limited to, colorimetric and luminescence detection methods, resonance energy transfer (RET) methods, time-resolved fluorescence (HTRF) methods, cell-based fluorescence assays, such as fluorescence resonance energy transfer (FRET) procedures (see, *e.g.*,Gonzalez et al., *Biophys. J.*, 69:1272-1280 (1995)), fluorescence polarization or anisotropy methods (see, *e.g.*, Jameson et al., *Methods Enzymol.*, 246:283-300 (1995); Jolley, *J. Biomol. Screening*, 1:33-38 (1996); Lynch et al., *Anal. Biochem.*, 247:77-82 (1997)), fluorescence correlation spectroscopy (FCS) and other such methods.

2. Test Substances

Test compounds, including small molecules, antibodies, proteins, nucleic acids, peptides, and libraries and collections thereof, can be screened in the above-described assays and assays described below to identify compounds that modulate the activity an MTSP7 protein.

Rational drug design methodologies that rely on computational chemistry can be used to screen and identify candidate compounds.

The compounds identified by the screening methods include inhibitors, including antagonists, and can be agonists Compounds for screening are any compounds and collections of compounds available, know or that can be prepared.

a. Selection of Compounds

Compounds can be selected for their potency and selectivity of inhibition of serine proteases, especially an MTSP7 protein. As described herein, and as generally known, a target serine protease and its substrate are combined under assay conditions permitting reaction of the protease with its substrate. The assay is performed in the absence of test compound, and in the presence of increasing concentrations of the test compound. The concentration of test compound at which 50% of the serine protease activity is inhibited by the test compound is the IC_{50} value (Inhibitory Concentration) or EC_{50} (Effective Concentration) value for that compound. Within a series or group of test compounds, those having lower IC_{50} or EC_{50} values are considered more potent inhibitors of the serine protease than those compounds having higher IC_{50} or EC_{50} values. The IC_{50} measurement is often used for more simplistic assays, whereas the EC_{50} is often used for more complicated assays, such as those employing cells.

Typically candidate compounds have an IC_{50} value of 100 nM or less as measured in an *in vitro* assay for inhibition of MTSP7 protein activity. The test compounds also are evaluated for selectivity toward a serine protease. As described herein, and as generally known, a test compound is assayed for its potency toward a panel of serine proteases and other enzymes and an IC_{50} value or EC_{50} value is determined for each test compound in each assay system. A compound that demonstrates a low IC_{50} value or EC_{50} value for the target enzyme, *e.g.*, MTSP7 protein, and a higher IC_{50} value or EC_{50} value for other enzymes within the test

panel (*e.g.*, urokinase tissue plasminogen activator, thrombin, Factor Xa), is considered to be selective toward the target enzyme. Generally, a compound is deemed selective if its IC_{50} value or EC_{50} value in the target enzyme assay is at least one order of magnitude less than the next smallest IC_{50} value or EC_{50} value measured in the selectivity panel of enzymes.

Compounds also are evaluated for their activity *in vivo*. The type of assay chosen for evaluation of test compounds will depend on the pathological condition to be treated or prevented by use of the compound, as well as the route of administration to be evaluated for the test compound.

For instance, to evaluate the activity of a compound to reduce tumor growth through inhibition of MTSP7 protein, the procedures described by Jankun et al., *Canc. Res.*, 57:559-563 (1997) to evaluate PAI-1 can be employed. Briefly, the ATCC cell lines DU145 and LnCaP are injected into SCID mice. After tumors are established, the mice are given test compound according to a dosing regime determined from the compound's *in vitro* characteristics. The Jankun *et al.* compound was administered in water. Tumor volume measurements are taken twice a week for about five weeks. A compound is deemed active if an animal to which the compound was administered exhibited decreased tumor volume, as compared to animals receiving appropriate control compounds.

Another *in vivo* experimental model designed to evaluate the effect of p-aminobenzamidine, a swine protease inhibitor, on reducing tumor volume is described by Billström et al., *Int. J. Cancer*, 61:542-547 (1995).

To evaluate the ability of a compound to reduce the occurrence of, or inhibit, metastasis, the procedures described by Kobayashi et al., *Int. J. Canc.*, 57:727-733d (1994) can be employed. Briefly, a murein xenograft selected for high lung colonization potential in injected into C57B1/6 mice i.v. (experimental metastasis) or s.c. into the abdominal

wall (spontaneous metastasis). Various concentrations of the compound to be tested can be admixed with the tumor cells in Matrigel prior to injection. Daily i.p. injections of the test compound are made either on days 1-6 or days 7-13 after tumor inoculation. The animals are sacrificed about three or four weeks after tumor inoculation, and the lung tumor colonies are counted. Evaluation of the resulting data permits a determination as to efficacy of the test compound, optimal dosing and route of administration.

The activity of the tested compounds toward decreasing tumor volume and metastasis can be evaluated in known models (see, e.g., Rabbani et al., *Int. J. Cancer* 63:840-845 (1995)). Evaluation of the resulting data permits a determination of the efficacy of a test compound, optimal dosing, and route of administration (see, also, Xing et al., *Canc. Res.*, 57:3585-3593 (1997), which describes a related protocol).

To evaluate the anti-angiogenesis activity of a compound, a rabbit cornea neovascularization model can be employed (see, *e.g.*, Avery *et al.* (1990) *Arch. Ophthalmol.*, 108:1474-147). Averu *et al.* describes anesthetizing New Zealand albino rabbits and then making a central corneal incision and forming a radial corneal pocket. A slow-release prostaglandin pellet was placed in the pocket to induce neovascularization. Test compound was administered i.p. for five days, at which time the animals were sacrificed. The effect of the test compound is evaluated by review of periodic photographs taken of the limbus, which can be used to calculate the area of neovascular response and, therefore, limbal neovascularization. A decreased area of neovascularization as compared with appropriate controls indicates the test compound was effective at decreasing or inhibiting neovascularization.

An angiogenesis model used to evaluate the effect of a test compound in preventing angiogenesis is described by Min et al., *Canc. Res.*, 56:2428-2433 (1996). C57BL6 mice receive subcutaneous

injections of a Matrigel mixture containing bFGF, as the angiogenesis-inducing agent, with and without the test compound. After five days, the animals are sacrificed and the Matrigel plugs, in which neovascularization can be visualized, are photographed. An experimental animal receiving Matrigel and an effective dose of test compound will exhibit less vascularization than a control animal or an experimental animal receiving a less- or non-effective does of compound.

An *in vivo* system designed to test compounds for their ability to limit the spread of primary tumors is described by Crowley et al., *Proc. Natl. Acad. Sci.*, 90:5021-5025 (1993). Nude mice are injected with tumor cells (PC3) engineered to express CAT (chloramphenicol acetyltransferase). Compounds to be tested for their ability to decrease tumor size and/or metastases are administered to the animals, and subsequent measurements of tumor size and/or metastatic growths are made. In addition, the level of CAT detected in various organs provides an indication of the ability of the test compound to inhibit metastasis; detection of less CAT in tissues of a treated animal versus a control animal indicates less CAT-expressing cells migrated to that tissue.

In vivo experimental modes designed to evaluate the inhibitory potential of a test serine protease inhibitors, using a tumor cell line F3II, the to be highly invasive, are described by Alonso et al., *Breast Canc. Res. Treat.*, 40:209-223 (1996). This group describes *in vivo* studies for toxicity determination, tumor growth, invasiveness, spontaneous metastasis, experimental lung metastasis, and an angiogenesis assay.

The CAM model (chick embryo chorioallantoic membrane model), first described by L. Ossowski in 1998 (*J. Cell Biol.*, 107:2437-2445 (1988)), provides another method for evaluating the inhibitory activity of a test compound. In the CAM model, tumor cells invade through the chorioallantoic membrane containing CAM with tumor cells in the presence of several serine protease inhibitors results in less or no invasion of the tumor cells through the membrane. Thus, the CAM assay is

performed with CAM and tumor cells in the presence and absence of various concentrations of test compound. The invasiveness of tumor cells is measured under such conditions to provide an indication of the compound's inhibitory activity. A compound having inhibitory activity correlates with less tumor invasion.

The CAM model is also used in a standard assay of angiogenesis (*i.e.*, effect on formation of new blood vessels (Brooks et al., *Methods in Molecular Biology*, 129:257-269 (1999)). According to this model, a filter disc containing an angiogenesis inducer, such as basic fibroblast growth factor (bFDG) is placed onto the CAM. Diffusion of the cytokine into the CAM induces local angiogenesis, which can be measured in several ways such as by counting the number of blood vessel branch points within the CAM directly below the filter disc. The ability of identified compounds to inhibit cytokine-induced angiogenesis can be tested using this model. A test compound can either be added to the filter disc that contains the angiogenesis inducer, be placed directly on the membrane or be administered systemically. The extent of new blood vessel formation in the presence and/or absence of test compound can be compared using this model. The formation of fewer new blood vessels in the presence of a test compound would be indicative of anti-angiogenesis activity. Demonstration of anti-angiogenesis activity for inhibitors of an MTSP7 protein indicates a role in angiogenesis for that MTSP protein.

b. Known serine protease inhibitors

Compounds for screening can be serine protease inhibitors, which can be tested for their ability to inhibit the activity of an MTSP7.

Exemplary, but not limiting serine proteases, include the following known serine protease inhibitors are used in the screening assays: Serine Protease Inhibitor 3 (SPI-3) (Chen, M.C., et al., *Citokine*, 11(11):856-862 (1999)); Aprotinin (Iijima, R., et al., *J. Biochem. (Tokyo)*, 126(5):912-916 (1999)); Kazal-type serine protease inhibitor-like proteins (Niimi, T., et al., *Eur. J. Biochem.*, 266(1):282-292 (1999)); Kunitz-type serine protease

inhibitor (Ravichandran, S., et al., *Acta Crystallogr. D. Biol. Crystallogr.*, 55(11):1814-1821 (1999)); Tissue factor pathway inhibitor-2/Matrix-associated serine rotease inhibitor (TFPI-2/MSPI), (Liu, Y., et al., *Arch. Biochem. Biophys.*, 370(1):112-8 (1999)); Bukunin, (Cui, C.Y., et al., *J. Invest. Dermatol.*, 113(2):182-8 (1999)); Nafmostat mesilate (Ryo, R., et al., *Vox Sang.*, 76(4):241-6 (1999)); TPCK (Huang, Y., et al., *Oncogene*, 18(23):3431-9 (1999)); A synthetic cotton-bound serine protease inhibitor (Edwards, J.V., et al., *Wound Repair Regen.*, 7(2):106-18 (1999)); FUT-175 (Sawada, M., et al., *Stroke*, 30(3):644-50 (1999)); Combination of serine protease inhibitor FUT-0175 and thromboxane synthetase inhibitor OKY-046 (Kaminogo, M., et al., *Neurol. Med. Chir. (Tokyo)*, 38(11):704-8; discussion 708-9 (1998)); The rat serine protease inhibitor 2.1 gene (LeCam, A., et al., *Biochem. Biophys. Res. Commun.*, 253(2):311-4 (1998)); A new intracellular serine protease inhibitor expressed in the rat pituitary gland complexes with granzyme B (Hill, R.M., et al., *FEBS Lett.*, 440(3):361-4 (1998)); 3,4-Dichloroisocoumarin (Hammed, A., et al., *Proc. Soc. Exp. Biol. Med.*, 219(2):132-7 (1998)); LEX032 (Bains, A.S., et al., *Eur. J. Pharmacol.*, 356(1):67-72 (1998)); N-tosyl-L-phenylalanine chloromethyl ketone (Dryjanski, M., et al., *Biochemistry*, 37(40):14151-6 (1998)); Mouse gene for the serine protease inhibitor neuroserpin (P112) (Berger, P., et al., *Gene*, 214(1-2):25-33 (1998)); Rat serine protease inhibitor 2.3 gene (Paul, C., et al., *Eur. J. Biochem.*, 254(3):538-46 (1998)); Ecotin (Yang, S.Q., et al., *J. Mol. Biol.*, 279(4):945-57 (1998)); A 14 kDa plant-related serine protease inhibitor (Roch, P., et al., *Dev. Comp. Immunol.*, 22(1):1-12 (1998)); Matrix-associated serine protease inhibitor TFPI-2/33 kDa MSPI (Rao, C.N., et al., *Int. J. Cancer*, 76(5):749-56 (1998)); ONO-3403 (Hiwasa, T., et al., *Cancer Lett.*, 126(2):221-5 (1998)); Bdellastasin (Moser, M., et al., *Eur. J. Biochem.*, 253(1):212-20 (1998)); Bikunin (Xu, Y., et al., *J. Mol. Biol.*, 276(5):955-66 (1998)); Nafamostat mesilate (Mellgren, K., et al., *Thromb. Haemost.*, 79(2):342-7 (1998)); The growth hormone

dependent serine protease inhibitor, Spi 2.1 (Maake, C., et al., *Endocrinology*, 138(12):5630-6 (1997)); Growth factor activator inhibitor type 2, a Kunitz-type serine protease inhibitor (Kawaguchi, T., et al., *J. Biol. Chem.*, 272(44):27558-64 (1997)); Heat-stable serine protease inhibitor protein from ovaries of the desert locust, Schistocerga gregaria (Hamdaoui, A., et al., *Biochem. Biophys. Res. Commun.*, 238(2):357-60 (1997)); Bikunin, (Delaria, K.A., et al., *J. Biol. Chem.*, 272(18):12209-14 (1997)); Human placental bikunin (Marlor, C.W., et al., *J. Biol. Chem.*, 272(10):12202-8 (1997)); Hepatocyte growth factor activator inhibitor, a novel Kunitz-type serine protease inhibitor (Shimomura, T., et al., *J. Biol. Chem.*, 272(10):6370-6 (1997)); FUT-187, oral serine protease inhibitor, (Shiozaki, H., et al., *Gan To Kaguku Ryoho*, 23(14): 1971-9 (1996)); Extracellular matrix-associated serine protease inhibitors (Mr 33,000, 31,000, and 27,000 (Rao, C.N., et al., *Arch. Biochem. Biophys.*, 335(1):82-92 (1996)); An irreversible isocoumarin serine protease inhibitor (Palencia, D.D., et al., *Biol. Reprod.*, 55(3):536-42 (1996)); 4-(2-aminoethyl)-benzenesulfonyl fluoride (AEBSF) (Nakabo, Y., et al., *J. Leukoc. Biol.*, 60(3):328-36 (1996)); Neuroserpin (Osterwalder, T., et al., *EMBO J.*, 15(12):2944-53 (1996)); Human serine protease inhibitor alpha-1-antitrypsin (Forney, J.R., et al., *J. Parasitol.* 82(3):496-502 (1996)); Rat serine protease inhibitor 2.3 (Simar-Blanchet, A.E., et al., *Eur. J. Biochem.*, 236(2):638-48 (1996)); Gebaxate mesilate (parodi, F., et al., *J. Cardiothorac. Vasc. Anesth.*, 10(2):235-7 (1996)); Recombinant serine protease inhibitor, CPTI II (Stankiewicz, M., et al., (*Acta Biochim. Pol.*, 43(3):525-9 (1996)); A cysteine-rich serine protease inhibitor (Guamerin II) (Kim, D.R., et al., *J. Enzym. Inhib.*, 10(2):81-91 (1996)); Diisopropylfluorophosphate (Lundqvist, H., et al., *Inflamm. Res.*, 44(12):510-7 (1995)); Nexin 1 (Yu, D.W., et al., *J. Cell Sci.*, 108(Pt 12):3867-74 (1995)); LEX032 (Scalia, R., et al., *Shock*, 4(4):251-6 (1995)); Protease nexin I (Houenou, L.J., et al., *Proc. Natl. Acad. Sci. U.S.A.*, 92(3):895-9 (1995)); Chymase-directed serine protease inhibitor

(Woodard S.L., et al., *J. Immunol.*, 153(11):5016-25 (1994)); N-alpha-tosyl-L-lysyl-chloromethyl ketone (TLCK) (Bourinbaiar, A.S., et al., *Cell Immunol.*, 155(1):230-6 (1994)); Smpi56 (Ghendler, Y., et al., *Exp. Parasitol.*, 78(2):121-31 (1994)); Schistosoma haematobium serine protease (Blanton, R.E., et al., *Mol. Biochem. Parasitol.*, 63(1):1-11 (1994)); Spi-1 (Warren, W.C., et al., *Mol. Cell Endocrinol.*, 98(1):27-32 (1993)); TAME (Jessop, J.J., et al., *Inflammation*, 17(5):613-31 (1993)); Antithrombin III (Kalaria, R.N., et al., *Am. J. Pathol.*, 143(3):886-93 (1993)); FOY-305 (Ohkoshi, M., et al., *Anticancer Res.*, 13(4):963-6 (1993)); Camostat mesilate (Senda, S., et al., *Intern. Med.*, 32(4):350-4 (1993)); Pigment epithelium-derived factor (Steele, F.R., et al., *Proc. Natl. Acad. Sci. U.S.A.*, 90(4):1526-30 (1993)); Antistasin (Holstein, T.W., et al., *FEBS Lett.*, 309(3):288-92 (1992)); The vaccinia virus K2L gene encodes a serine protease inhibitor (Zhou, J., et al., *Virology*, 189(2):678-86 (1992)); Bowman-Birk serine-protease inhibitor (Werner, M.H., et al., *J. Mol. Biol.*, 225(3):873-89 (1992); FUT-175 (Yanamoto, H., et al., *Neurosurgery*, 30(3):358-63 (1992)); FUT-175; (Yanamoto, H., et al., *Neurosurgery*, 30(3):351-6, discussion 356-7 (1992)); PAI-I (Yreadwell, B.V., et al., *J. Orthop. Res.*, 9(3):309-16 (1991)); 3,4-Dichloroisocoumarin (Rusbridge, N.M., et al., *FEBS Lett.*, 268(1):133-6 (1990)); Alpha 1-antichymotrypsin (Lindmark, B.E., et al., *Am. Rev. Respir. Des.*, 141(4 Pt 1):884-8 (1990)); P-toluenesulfonyl-L-arginine methyl ester (TAME) (Scuderi, P., *J. Immunol.*, 143(1):168-73 (1989)); Aprotinin (Seto, S., et al., *Adv. Exp. Med. Biol.*, 247B:49-54 (1989)); Alpha 1-antichymotrypsin (Abraham, C.R., et al., *Cell*, 52(4):487-501 (1988)); Contrapsin (Modha, J., et al., *Parasitology*, 96 (Pt 1):99-109 (1988)); (FOY-305) (Yamauchi, Y., et al., *Hiroshima J. Med. Sci.*, 36(1):81-7 No abstract available (1987)); Alpha 2-antiplasmin (Holmes, W.E., et al., *J. Biol. Chem.*, 262(4):1659-64 (1987)); 3,4-dichloroisocoumarin (Harper, J.W., et al., *Biochemistry*, 24(8):1831-41 (1985)); Diisoprophylfluorophosphate (Tsutsui, K., et al., *Biochem.*

Biophys. Res. Commun., 123(1):271-7 (1984)); Gabexate mesilate (Hesse, B., et al., *Pharmacol. Res. Commun.*, 16(7):637-45 (1984)); Phenyl methyl sulfonyl fluoride (Dufer, J., et al., *Scand. J. Haematol.*, 32(1):25-32 (1984)); Aprotinin (Seto, S., et al., *Hypertension*, 5(6):893-9 (1983)); Protease inhibitor CI-2 (McPhalen, C.A., et al., *J. Mol. Biol.*, 168(2):445-7 (1983)); Phenylmethylsulfonyl fluoride (Sekar V., et al., *Biochem. Biophys. Res. Commun.*, 89(2):474-8 (1979)); PGE1 (Feinstein, M.D., et al., *Prostaglandine*, 14(6):1075-93 (1977)

c. Combinatorial libraries and other libraries

The source of compounds for the screening assays, can be libraries, including, but are not limited to, combinatorial libraries. Methods for synthesizing combinatorial libraries and characteristics of such combinatorial libraries are known in the art (*See generally, Combinatorial Libraries: Synthesis, Screening and Application Potential* (Cortese Ed.) Walter de Gruyter, Inc., 1995; Tietze and Lieb, *Curr. Opin. Chem. Biol.*, 2(3):363-71 (1998); Lam, *Anticancer Drug Des.*, 12(3):145-67 (1997); Blaney and Martin, *Curr. Opin. Chem. Biol.*, 1(1):54-9 (1997); and Schultz and Schultz, *Biotechnol. Prog.*, 12(6):729-43 (1996)).

Methods and strategies for generating diverse libraries, primarily peptide- and nucleotide-based oligomer libraries, have been developed using molecular biology methods and/or simultaneous chemical synthesis methodologies (*see, e.g.*, Dower et al., *Annu. Rep. Med. Chem.*, 26:271-280 (1991); Fodor et al., *Science*, 251:767-773 (1991); Jung et al., *Angew. Chem. Ind. Ed. Engl.*, 31:367-383 (1992); Zuckerman et al., *Proc. Natl. Acad. Sci. USA*, 89:4505-4509 (1992); Scott et al., *Science*, 249:386-390 (1990); Devlin et al., *Science*, 249:404-406 (1990); Cwirla et al., *Proc. Natl. Acad. Sci. USA*, 87:6378-6382 (1990); and Gallop et al., *J. Medicinal Chemistry*, 37:1233-1251 (1994)). The resulting combinatorial libraries potentially contain millions of compounds and that can be screened to identify compounds that exhibit a selected activity.

The libraries fall into roughly three categories: fusion-protein-displayed peptide libraries in which random peptides or proteins are presented on the surface of phage particles or proteins expressed from plasmids; support-bound synthetic chemical libraries in which individual compounds or mixtures of compounds are presented on insoluble matrices, such as resin beads (*see, e.g.*, Lam et al., *Nature*, 354:82-84 (1991)) and cotton supports (*see, e.g.*, Eichler et al., *Biochemistry* 32:11035-11041 (1993)); and methods in which the compounds are used in solution (*see, e.g.*, Houghten et al., *Nature*, 354:84-86 (1991); Houghten et al., *BioTechniques*, 313:412-421 (1992); and Scott et al., *Curr. Opin. Biotechnol.*, 5:40-48 (1994)). There are numerous examples of synthetic peptide and oligonucleotide combinatorial libraries and there are many methods for producing libraries that contain non-peptidic small organic molecules. Such libraries can be based on basis set of monomers that are combined to form mixtures of diverse organic molecules or that can be combined to form a library based upon a selected pharmacophore monomer.

Either a random or a deterministic combinatorial library can be screened by the presently disclosed and/or claimed screening methods. In either of these two libraries, each unit of the library is isolated and/or immobilized on a solid support. In the deterministic library, one knows *a priori* a particular unit's location on each solid support. In a random library, the location of a particular unit is not known *a priori* although each site still contains a single unique unit. Many methods for preparing libraries are known to those of skill in this art (see, *e.g.*, Geysen et al., *Proc. Natl. Acad. Sci. USA*, 81:3998-4002 (1984), Houghten et al., *Proc. Natl. Acad. Sci. USA*, 81:5131-5135 (1985)). Combinatorial library generated by the any techniques known to those of skill in the art are contemplated (see, *e.g.*, Table 1 of Schultz and Schultz, *Biotechnol. Prog.*, 12(6):729-43 (1996)) for screening; Bartel *et al.*, *Science*, 261:1411-1418 (1993); Baumbach *et al. BioPharm*, (Can):24-35 (1992);

Bock *et al. Nature*, 355:564-566 (1992); Borman, S., Combinatorial chemists focus on samll molecules molecular recognition, and automation, *Chem. Eng. News*, 2(12):29 (1996); Boublik, et al., Eukaryotic Virus Display: Engineering the Major Surface Glycoproteins of the Autographa California Nuclear Polyhedrosis Virus (ACNPV) for the Presentation of Foreign Proteins on the Virus Surface, *Bio/Technology*, 13:1079-1084 (1995); Brenner, et al., Encoded Combinatorial Chemistry, *Proc. Natl. Acad Sci. U.S.A.*, 89:5381-5383 (1992); Caflisch, et al., Computational Combinatorial Chemistry for *De Novo* Ligand Design: Review and Assessment, *Perspect. Drug Discovery Des.*, 3:51-84 (1995); Cheng, et al., Sequence-Selective Peptide Binding with a Peptido-A,B-*trans*-steroidal Receptor Selected from an Encoded Combinatorial Library, *J. Am. Chem. Soc.*, 118:1813-1814 (1996); Chu, et al., Affinity Capillary Electrophoresis to Identify the Peptide in A Peptide Library that Binds Most Tightly to Vancomycin, *J. Org. Chem.*, 58:648-652 (1993); Clackson, et al., Making Antibody Fragments Using Phage Display Libraries, *Nature*, 352:624-628 (1991); Combs, et al., Protein Structure-Based Combinatorial Chemistry: Discovery of Non-Peptide Binding Elements to Src SH3 Domain, *J. Am. Chem. Soc.*, 118:287-288 (1996); Cwirla, et al., Peptides On Phage: A Vast Library of Peptides for Identifying Ligands, *Proc. Natl. Acad. Sci. U.S.A.*, 87:6378-6382 (1990); Ecker, et al., Combinatorial Drug Discovery: Which Method will Produce the Greatest Value, *Bio/Technology*, 13:351-360 (1995); Ellington, et al., *In Vitro* Selection of RNA Molecules That Bind Specific Ligands, *Nature*, 346:818-822 (1990); Ellman, J.A., Variants of Benzodiazephines, *J. Am. Chem. Soc.*, 114:10997 (1992); Erickson, et al., *The Proteins*; Neurath, H., Hill, R.L., Eds.: Academic: New York, 1976; pp. 255-257; Felici, et al., *J. Mol. Biol.*, 222:301-310 (1991); Fodor, et al., Light-Directed, Spatially Addressable Parallel Chemical Synthesis, *Science*, 251:767-773 (1991); Francisco, et al., Transport and Anchoring of Beta-Lactamase to the External Surface of *E. Coli.*, *Proc. Natl. Acad. Sci. U.S.A.*, 89:2713-

2717 (1992); Georgiou, et al., Practical Applications of Engineering Gram-Negative Bacterial Cell Surfaces, *TIBTECH*, 11:6-10 (1993); Geysen, et al., Use of peptide synthesis to probe viral antigens for epitopes to a resolution of a single amino acid, *Proc. Natl. Acad. Sci. U.S.A.*, 81:3998-4002 (1984); Glaser, et al., Antibody Engineering by Condon-Based Mutagenesis in a Filamentous Phage Vector System, *J. Immunol.*, 149:3903-3913 (1992); Gram, et al., In vitro selection and affinity maturation of antibodies from a naive combinatorial immunoglobulin library, *Proc. Natl. Acad. Sci.*, 89:3576-3580 (1992); Han, et al., Liquid-Phase Combinatorial Synthesis, *Proc. Natl. Acad. Sci. U.S.A.*, 92:6419-6423 (1995); Hoogenboom, et al., Multi-Subunit Proteins on the Surface of Filamentous Phage: Methodologies for Displaying Antibody (Fab) Heavy and Light Chains, *Nucleic Acids Res.*, 19:4133-4137 (1991); Houghten, et al., General Method for the Rapid Solid-Phase Synthesis of Large Numbers of Peptides: Specificity of Antigen-Antibody Interaction at the Level of Individual Amino Acids, *Proc. Natl. Acad. Sci. U.S.A.*, 82:5131-5135 (1985); Houghten, et al., The Use of Synthetic Peptide Combinatorial Libraries for the Determination of Peptide Ligands in Radio-Receptor Assays-Opiod-Peptides, *Bioorg. Med. Chem. Lett.*, 3:405-412 (1993); Houghten, et al., Generation and Use of Synthetic Peptide Combinatorial Libraries for Basic Research and Drug Discovery, *Nature*, 354:84-86 (1991); Huang, et al., Discovery of New Ligand Binding Pathways in Myoglobin by Random Mutagenesis, *Nature Struct. Biol.*, 1:226-229 (1994); Huse, et al., Generation of a Large Combinatorial Library of the Immunoglobulin Repertoire In Phage Lambda, *Science*, 246:1275-1281 (1989); Janda, K.D., New Strategies for the Design of Catalytic Antibodies, *Biotechnol. Prog.*, 6:178-181 (1990); Jung, et al., Multiple Peptide Synthesis Methods and Their Applications, *Angew. Chem. Int. Ed. Engl.*, 31:367-486 (1992); Kang, et al., Linkage of Recognition and Replication Functions By Assembling Combinatorial Antibody Fab Libraries Along Phage Surfaces, *Proc. Natl. Acad. Sci.*

U.S.A., 88:4363-4366 (1991a); Kang, et al., Antibody Redesign by Chain Shuffling from Random Combinatorial Immunoglobulin Libraries, *Proc. Natl. Acad. Sci. U.S.A.*, 88:11120-11123 (1991b); Kay, et al., An M13 Phage Library Displaying Random 38-Amino-Acid-Peptides as a Source of Novel Sequences with Affinity to Selected Targets Genes, *Gene*, 128:59-65 (1993); Lam, et al., A new type of synthetic peptide library for identifying ligand-binding activity, *Nature*, 354:82-84 (1991) (published errata apear in *Nature*, 358:434 (1992) and *Nature*, 360:768 (1992); Lebl, et al., One Bead One Structure Combinatorial Libraries, *Biopolymers (Pept. Sci.)*, 37:177-198 (1995); Lerner, et al., Antibodies without Immunization, *Science*, 258:1313-1314 (1992); Li, et al., Minimization of a Polypeptide Hormone, *Science*, 270:1657-1660 (1995); Light, et al., Display of Dimeric Bacterial Alkaline Phosphatase on the Major Coat Protein of Filamentous Bacteriophage, *Bioorg. Med. Chem. Lett.*, 3:1073-1079 (1992); Little, et al., Bacterial Surface Presentation of Proteins and Peptides: An Alternative to Phage Technology, *Trends Biotechnol.*, 11:3-5 (1993); Marks, et al., By-Passing Immunization. Human Antibodies from V-Gene Libraries Displayed on Phage, *J. Mol. Biol.*, 222:581-597 (1991); Matthews, et al., Substrate Phage: Selection of Protease Substrates by Monovalent Phage Display, *Science*, 260:1113-1117 (1993); McCafferty, et al., Phage Enzymes: Expression and Affinity Chromatography of Functional Alkaline Phosphatase on the Surface of Bacteriophage, *Protein Eng.*, 4:955-961 (1991); Menger, et al., Phosphatase Catalysis Developed Via Combinatorial Organic Chemistry, *J. Org. Chem.*, 60:6666-6667 (1995); Nicolaou, et al., *Angew. Chem. Int. Ed. Engl.*, 34:2289-2291 (1995); Oldenburg, et al., Peptide Ligands for A Sugar-Binding Protein Isolated from a Random Peptide Library, *Proc. Natl. Acad. Sci. U.S.A.*, 89:5393-5397 (1992); Parmley, et al., Antibody-Selectable Filamentous fd Phage Vectors: Affinity Purification of Target Genes, *Genes*, 73:305-318 (1988); Pinilla, et al., Synthetic Peptide Combinatorial Libraries (SPCLS)--Identification of the Antigenic Determinant of Beta-Endorphin

Recognized by Monoclonal Antibody-3E7, *Gene*, 128:71-76 (1993); Pinilla, et al., Review of the Utility of Soluble Combinatorial Libraries, *Biopolymers*, 37:221-240 (1995); Pistor, et al., Expression of Viral Hemegglutinan On the Surface of *E. Coli.*, *Klin. Wochenschr.*, 66:110-116 (1989); Pollack, et al., Selective Chemical Catalysis by an Antibody, *Science*, 234:1570-1572 (1986); Rigler, et al., Fluorescence Correlations, Single Molecule Detection and Large Number Screening: Applications in Biotechnology, *J. Biotechnol.*, 41:177-186 (1995); Sarvetnick, et al., Increasing the Chemical Potential of the Germ-Line Antibody Repertoire, *Proc. Natl. Acad. Sci. U.S.A.*, 90:4008-4011 (1993); Sastry, et al., Cloning of the Immunological Repertiore in *Escherichia Coli* for Generation of Monoclonal Catalytic Antibodies: Construction of a Heavy Chain Variable Region-Specific cDNA Library, *Proc. Natl. Acad. Sci. U.S.A.*, 86:5728-5732 (1989); Scott, et al., Searching for Peptide Ligands with an Epitope Library, *Science*, 249:386-390 (1990); Sears, et al., Engineering Enzymes for Bioorganic Synthesis: Peptide Bond Formation, *Biotechnol. Prog.*, 12:423-433 (1996); Simon, et. al., Peptides: A Modular Approach to Drug Discovery, *Proc. Natl. Acad. Sci. U.S.A.*, 89:9367-9371 (1992); Still, et al., Discovery of Sequence-Selective Peptide Binding by Synthetic Receptors Using Encoded Combinatorial Libraries, *Acc. Chem. Res.*, 29:155-163 (1996); Thompson, et al., Synthesis and Applications of Small Molecule Libraries, *Chem. Rev.*, 96:555-600 (1996); Tramontano, et al., Catalytic Antibodies, *Science*, 234:1566-1570 (1986); Wrighton, et al., Small Peptides as Potent Mimetics of the Protein Hormone Erythropoietin, *Science*, 273:458-464 (1996); York, et al., Combinatorial mutagenesis of the reactive site region in plasminogen activator inhibitor I, *J. Biol. Chem.*, 266:8595-8600 (1991); Zebedee, et al., Human Combinatorial Antibody Libraries to Hepatitis B Surface Antigen, *Proc. Natl. Acad. Sci. U.S.A.*, 89:3175-3179 (1992); Zuckerman, et al., Identification of Highest-Affinity Ligands by

Affinity Selection from Equimolar Peptide Mixtures Generated by Robotic Synthesis, *Proc. Natl. Acad. Sci. U.S.A.*, 89:4505-4509 (1992).

For example, peptides that bind to an MTSP7 protein or a protease domain of an MTSP protein can be identified using phage display libraries. In an exemplary embodiment, this method can include a) contacting phage from a phage library with the MTSP7 protein or a protease domain thereof; (b) isolating phage that bind to the protein; and (c) determining the identity of at least one peptide coded by the isolated phage to identify a peptide that binds to an MTSP7 protein.

H. Modulators of the activity of MTSP7 proteins

Provided herein are compounds, identified by screening or produced using the MTSP7 protein or protease domain in other screening methods, that modulate the activity of an MTSP7. These compounds act by directly interacting with the MTSP7 protein or by altering transcription or translation thereof. Such molecules include, but are not limited to, antibodies that specifically react with an MTSP7 protein, particularly with the protease domain thereof, antisense nucleic acids that alter expression of the MTSP7 protein or dsRNA, such as RNAi,, antibodies, peptide mimetics and other such compounds.

1. Antibodies

Antibodies, including polyclonal and monoclonal antibodies, that specifically bind to the MTSP7 protein provided herein, particularly to the single chain protease domains thereof or the activated forms of the full-length or protease domain or the zymogen form, are provided. Typically, the antibody is a monoclonal antibody, and generally, the antibody specifically binds to the protease domain of the MTSP7 protein. In particular embodiments, antibodies to each of the single chain of the protease domain of MTSP7 are provided. Also provided are antibodies that specifically bind to any domain of MTSP7 and to two chain forms thereof.

The MTSP7 protein and domains, fragments, homologs and derivatives thereof can be used as immunogens to generate antibodies that specifically bind such immunogens. Such antibodies include but are not limited to polyclonal, monoclonal, chimeric, single chain, Fab fragments, and an Fab expression library. In a specific embodiment, antibodies to human MTSP7 protein are produced. In another embodiment, complexes formed from fragments of MTSP7 protein, which fragments contain the serine protease domain, are used as immunogens for antibody production.

Various procedures known in the art can be used for the production of polyclonal antibodies to MTSP7 protein, its domains, derivatives, fragments or analogs. For production of the antibody, various host animals can be immunized by injection with the native MTSP7 protein or a synthetic version, or a derivative of the foregoing, such as a cross-linked MTSP7 protein. Such host animals include but are not limited to rabbits, mice and rats. Various adjuvants can be used to increase the immunological response, depending on the host species, and include but are not limited to Freund's (complete and incomplete), mineral gels such as aluminum hydroxide, surface active substances such as lysolecithin, pluronic polyols, polyanions, peptides, oil emulsions, dinitrophenol, and potentially useful human adjuvants such as bacille Calmette-Guerin (BCG) and corynebacterium parvum.

For preparation of monoclonal antibodies directed towards an MTSP7 protein or domains, derivatives, fragments or analogs thereof, any technique that provides for the production of antibody molecules by continuous cell lines in culture can be used. Such techniques include but are not restricted to the hybridoma technique originally developed by Kohler and Milstein (*Nature* 256:495-497 (1975)), the trioma technique, the human B-cell hybridoma technique (Kozbor et al., *Immunology Today* 4:72 (1983)), and the EBV hybridoma technique to produce human monoclonal antibodies (Cole et al., *in Monoclonal Antibodies and Cancer*

Therapy, Alan R. Liss, Inc., pp. 77-96 (1985)). In an additional embodiment, monoclonal antibodies can be produced in germ-free animals utilizing recent technology (PCT/US90/02545). Human antibodies can be used and can be obtained by using human hybridomas (Cote et al., *Proc. Natl. Acad. Sci. USA* 80:2026-2030 (1983)). Or by transforming human B cells with EBV virus *in vitro* (Cole et al., *in Monoclonal Antibodies and Cancer Therapy,* Alan R. Liss, Inc., pp. 77-96 (1985)). Techniques developed for the production of "chimeric antibodies" (Morrison et al., *Proc. Natl. Acad. Sci. USA* 81:6851-6855 (1984); Neuberger et al., *Nature* 312:604-608 (1984); Takeda et al., *Nature* 314:452-454 (1985)) by splicing the genes from a mouse antibody molecule specific for the MTSP7 protein together with genes from a human antibody molecule of appropriate biological activity can be used.

Techniques described for the production of single chain antibodies (U.S. patent 4,946,778) can be adapted to produce MTSP7 protein-specific single chain antibodies. An additional embodiment uses the techniques described for the construction of Fab expression libraries (Huse et al., *Science* 246:1275-1281 (1989)) to allow rapid and easy identification of monoclonal Fab fragments with the desired specificity for MTSP7 protein or domains, derivatives, or analogs thereof. Non-human antibodies can be "humanized" by known methods (*see, e.g.*, U.S. Patent No. 5,225,539).

Antibody fragments that contain the idiotypes of MTSP7 protein can be generated by techniques known in the art. For example, such fragments include but are not limited to: the F(ab')2 fragment which can be produced by pepsin digestion of the antibody molecule; the Fab' fragments that can be generated by reducing the disulfide bridges of the F(ab')2 fragment, the Fab fragments that can be generated by treating the antibody molecular with papain and a reducing agent, and Fv fragments.

In the production of antibodies, screening for the desired antibody can be accomplished by techniques known in the art, *e.g.*, ELISA

(enzyme-linked immunosorbent assay). To select antibodies specific to a particular domain of the MTSP7 protein one can assay generated hybridomas for a product that binds to the fragment of the MTSP7 protein that contains such a domain

The foregoing antibodies can be used in methods known in the art relating to the localization and/or quantitation of MTSP7 protein proteins, *e.g.*, for imaging these proteins, measuring levels thereof in appropriate physiological samples, in, for example, diagnostic methods. In another embodiment, anti-MTSP7 protein antibodies, or fragments thereof, containing the binding domain are used as therapeutic agents.

2. Peptides, Polypetides and Peptide Mimetics

Provided herein are methods for identifying molecules that bind to and modulate the activity of MTSP proteins. Included among molecules that bind to MTSP7, particularly the single chain protease domain or catalytically active fragments thereof, are peptides, polypeptides and peptide mimetics, including cyclic peptides. Peptide mimetics are molecules or compounds that mimic the necessary molecular conformation of a ligand or polypeptide for specific binding to a target molecule such as an MTSP7 protein. In an exemplary embodiment, the peptides, peptides, polypeptides and peptide mimetics or peptide mimetics bind to the protease domain of the MTSP7 protein. Such peptides and peptide mimetics include those of antibodies that specifically bind an MTSP7 protein and, typically, bind to the protease domain of an MTSP7 protein. The peptides, polypeptides and peptide mimetics and peptide mimetics identified by methods provided herein can be agonists or antagonists of MTSP7 proteins.

Such peptides, polypeptides and peptide mimetics and peptide mimetics are useful for diagnosing, treating, preventing, and screening for a disease or disorder associated with MTSP7 protein activity in a mammal. In addition, the peptides, polypeptides and peptide mimetics are useful for identifying, isolating, and purifying molecules or compounds

that modulate the activity of an MTSP7 protein, or specifically bind to an MTSP7 protein, generally, the protease domain of an MTSP7 protein. Low molecular weight peptides and peptide mimetics can have strong binding properties to a target molecule, *e.g.*, an MTSP7 protein or, generally, to the protease domain of an MTSP7 protein.

Peptides, polypeptides and peptide mimetics that bind to MTSP7 proteins as described herein can be administered to mammals, including humans, to modulate MTSP7 protein activity. Thus, methods for therapeutic treatment and prevention of neoplastic diseases comprise administering a peptide, polypeptides or peptide mimetic compound in an amount sufficient to modulate such activity are provided. Thus, also provided herein are methods for treating a subject having such a disease or disorder in which a peptide, polypeptides or peptide mimetic compound is administered to the subject in a therapeutically effective dose or amount.

Compositions containing the peptides, polypeptides or peptide mimetics can be administered for prophylactic and/or therapeutic treatments. In therapeutic applications, compositions can be administered to a patient already suffering from a disease, as described above, in an amount sufficient to cure or at least partially arrest the symptoms of the disease and its complications. Amounts effective for this use will depend on the severity of the disease and the weight and general state of the patient.

In prophylactic applications, compositions containing the peptides, polypeptides and peptide mimetics are administered to a patient susceptible to or otherwise at risk of a particular disease. Such an amount is defined to be a "prophylactically effective dose". In this use, the precise amounts again depend on the patient's state of health and weight.

Accordingly, the peptides, polypeptides and peptide mimetics that bind to an MTSP7 protein can be used generating pharmaceutical compositions containing, as an active ingredient, at least one of the

peptides, polypeptides or peptide mimetics in association with a pharmaceutical carrier or diluent. The compounds can be administered, for example, by oral, pulmonary, parental (intramuscular, intraperitoneal, intravenous (IV) or subcutaneous injection), inhalation (via a fine powder formulation), transdermal, nasal, vaginal, rectal, or sublingual routes of administration and can be formulated in dosage forms appropriate for each route of administration (see, *e.g.*, International PCT application Nos. WO 93/25221 and WO 94/17784; and European Patent Application 613,683).

Peptides, polypeptides and peptide mimetics that bind to MTSP7 proteins are useful *in vitro* as unique tools for understanding the biological role of MTSP7 proteins, including the evaluation of the many factors thought to influence, and be influenced by, the production of MTSP7 protein. Such peptides, polypeptides and peptide mimetics are also useful in the development of other compounds that bind to and modulate the activity of an MTSP7 protein, because such compounds provide important information on the relationship between structure and activity that should facilitate such development.

The peptides, polypeptides and peptide mimetics are also useful as competitive binders in assays to screen for new MTSP7 proteins or MTSP7 protein agonists. In such assay embodiments, the compounds can be used without modification or can be modified in a variety of ways; for example, by labeling, such as covalently or non-covalently joining a moiety which directly or indirectly provides a detectable signal. In any of these assays, the materials thereto can be labeled either directly or indirectly. Possibilities for direct labeling include label groups such as: radiolabels such as ^{125}I enzymes (U.S. Pat. No. 3,645,090) such as peroxidase and alkaline phosphatase, and fluorescent labels (U.S. Pat. No. 3,940,475) capable of monitoring the change in fluorescence intensity, wavelength shift, or fluorescence polarization. Possibilities for indirect labeling include biotinylation of one constituent followed by binding to

avidin coupled to one of the above label groups. The compounds can also include spacers or linkers in cases where the compounds are to be attached to a solid support.

Moreover, based on their ability to bind to an MTSP7 protein, the peptides, polypeptides and peptide mimetics can be used as reagents for detecting MTSP7 proteins in living cells, fixed cells, in biological fluids, in tissue homogenates and in purified, natural biological materials. For example, by labelling such peptides, polypeptides and peptide mimetics, cells having MTSP7 proteins can be indentified. In addition, based on their ability to bind an MTSP7 protein, the peptides, polypeptides and peptide mimetics can be used in *in situ* staining, FACS (fluorescence-activated cell sorting), Western blotting, ELISA and other analytical protocols. Based on their ability to bind to an MTSP7 protein, the peptides, polypeptides and peptide mimetics can be used in purification of MTSP7 protein polypeptides or in purifying cells expressing the MTSP7 protein polypeptides, *e.g.*, a polypeptide encoding the protease domain of an MTSP7 protein.

The peptides, polypeptides and peptide mimetics can also be used as commercial reagents for various medical research and diagnostic uses. The activity of the peptides and peptide mimetics can be evaluated either *in vitro* or *in vivo* in one of the numerous models described in McDonald (1992) *Am. J. of Pediatric Hematology/Oncology, 14*:8-21.

3. Peptide, polypeptides and peptide mimetic therapy

Peptide analogs are commonly used in the pharmaceutical industry as non-peptide drugs with properties analogous to those of the template peptide. These types of non-peptide compounds are termed "peptide mimetics" or "peptidomimetics" (Luthman *et al.*, *A Textbook of Drug Design and Development, 14:386-406*, 2nd Ed., Harwood Academic Publishers (1996); Joachim Grante (1994) *Angew. Chem. Int. Ed. Engl., 33*:1699-1720; Fauchere (1986) *J. Adv. Drug Res., 15*:29; Veber and Freidinger (1985) *TINS*, p. 392; and Evans *et al.* (1987) *J. Med. Chem.*

30:1229). Peptide mimetics that are structurally similar to therapeutically useful peptides can be used to produce an equivalent or enhanced therapeutic or prophylactic effect. Preparation of peptidomimetics and structures thereof are known to those of skill in this art.

Systematic substitution of one or more amino acids of a consensus sequence with a D-amino acid of the same type (*e.g.*, D-lysine in place of L-lysine) can be used to generate more stable peptides. In addition, constrained peptides containing a consensus sequence or a substantially identical consensus sequence variation can be generated by methods known in the art (Rizo *et al.* (1992) *An. Rev. Biochem., 61*:387, incorporated herein by reference); for example, by adding internal cysteine residues capable of forming intramolecular disulfide bridges which cyclize the peptide.

Those skilled in the art would appreciate that modifications can be made to the peptides and mimetics without deleteriously effecting the biological or functional activity of the peptide. Further, the skilled artisan would know how to design non-peptide structures in three dimensional terms, that mimic the peptides that bind to a target molecule, *e.g.*, an MTSP7 protein or, generally, the protease domain of MTSP7 proteins (see, *e.g.*, Eck and Sprang (1989) *J. Biol. Chem., 26*: 17605-18795).

When used for diagnostic purposes, the peptides and peptide mimetics can be labeled with a detectable label and, accordingly, the peptides and peptide mimetics without such a label can serve as intermediates in the preparation of labeled peptides and peptide mimetics. Detectable labels can be molecules or compounds, which when covalently attached to the peptides and peptide mimetics, permit detection of the peptide and peptide mimetics *in vivo*, for example, in a patient to whom the peptide or peptide mimetic has been administered, or *in vitro*, *e.g.*, in a sample or cells. Suitable detectable labels are well known in the art and include, by way of example, radioisotopes, fluorescent labels (*e.g.*, fluorescein), and the like. The particular detectable label employed is not

critical and is selected relative to the amount of label to be employed as well as the toxicity of the label at the amount of label employed. Selection of the label relative to such factors is well within the skill of the art.

Covalent attachment of a detectable label to the peptide or peptide mimetic is accomplished by conventional methods well known in the art. For example, when the ^{125}I radioisotope is employed as the detectable label, covalent attachment of ^{125}I to the peptide or the peptide mimetic can be achieved by incorporating the amino acid tyrosine into the peptide or peptide mimetic and then iodinating the peptide (see, *e.g.*, Weaner *et al.* (1994) *Synthesis and Applications of Isotopically Labelled Compounds*, pp. 137-140). If tyrosine is not present in the peptide or peptide mimetic, incorporation of tyrosine to the N or C terminus of the peptide or peptide mimetic can be achieved by well known chemistry. Likewise, ^{32}P can be incorporated onto the peptide or peptide mimetic as a phosphate moiety through, for example, a hydroxyl group on the peptide or peptide mimetic using conventional chemistry.

Labeling of peptidomimetics usually involves covalent attachment of one or more labels, directly or through a spacer (*e.g.*, an amide group), to non-interfering position(s) on the peptidomimetic that are predicted by quantitative structure-activity data and/or molecular modeling. Such non-interfering positions generally are positions that do not form direct contacts with the macromolecules(s) to which the peptidomimetic binds to produce the therapeutic effect. Derivatization (*e.g.*, labeling) of peptidomimetics should not substantially interfere with the desired biological or pharmacological activity of the peptidomimetic.

Peptides, polypeptides and peptide mimetics that can bind to MTSP7 proteins or the protease domain of MTSP7 proteins and modulate the activity thereof, or have MTSP7 protein activity, can be used for treatment of neoplastic disease. The peptides, polypeptides and peptide mimetics can be delivered, *in vivo* or *ex vivo*, to the cells of a subject in

need of treatment. Further, peptides which have MTSP7 protein activity can be delivered, *in vivo* or *ex vivo*, to cells which carry mutant or missing alleles encoding the MTSP7 protein gene. Any of the techniques described herein or known to the skilled artisan can be used for preparation and *in vivo* or *ex vivo* delivery of such peptides, polypeptides and peptide mimetics that are substantially free of other human proteins. For example, the peptides, polypeptides and peptide mimetics can be readily prepared by expression in a microorganism or synthesis *in vitro*.

The peptides or peptide mimetics can be introduced into cells, *in vivo* or *ex vivo*, by microinjection or by use of liposomes, for example. Alternatively, the peptides, polypeptides or peptide mimetics can be taken up by cells, *in vivo* or *ex vivo*, actively or by diffusion. In addition, extracellular application of the peptide, polypeptides or peptide mimetic can be sufficient to effect treatment of a neoplastic disease. Other molecules, such as drugs or organic compounds, that: 1) bind to an MTSP7 protein or protease domain thereof; or 2) have a similar function or activity to an MTSP7 protein or protease domain thereof, can be used in methods for treatment.

4. Rational drug design

The goal of rational drug design is to produce structural analogs of biologically active polypeptides or peptides of interest or of small molecules or peptide mimetics with which they interact (e.g., agonists, antagonists, inhibitors) in order to fashion drugs which are, e.g., more active or stable forms thereof; or which, for example, enhance or interfere with the function of a polypeptide *in vivo* (e.g., an MTSP7 protein). In one approach, one first determines the three-dimensional structure of a protein of interest (e.g., an MTSP7 protein or polypeptide having a protease domain) or, for example, of a MTSP7 protein-ligand complex, by X-ray crystallography, by computer modeling or most typically, by a combination of approaches (see, *e.g.*, Erickson *et al.* 1990). Also, useful information regarding the structure of a polypeptide can be gained by

modeling based on the structure of homologous proteins. In addition, peptides can be analyzed by an alanine scan. In this technique, an amino acid residue is replaced by Ala, and its effect on the peptide's activity is determined. Each of the amino acid residues of the peptide is analyzed in this manner to determine the important regions of the peptide.

Also, a polypeptide or peptide that binds to an MTSP7 protein or, generally, the protease domain of an MTSP7 protein, can be selected by a functional assay, and then the crystal structure of this polypeptide or peptide can be determined. The polypeptide can be, for example, an antibody specific for an MTSP7 protein or the protein domain of an MTSP7 protein. This approach can yield a pharmacore upon which subsequent drug design can be based. Further, it is possible to bypass the crystallography altogether by generating anti-idiotypic polypeptides or peptides, (anti-ids) to a functional, pharmacologically active polypeptide or peptide that binds to an MTSP7 protein or protease domain of an MTSP7 protein. As a mirror image of a mirror image, the binding site of the anti-ids is expected to be an analog of the original target molecule, e.g., an MTSP7 protein or polypeptide having an MTSP7 protein. The anti-id could then be used to identify and isolate peptides from banks of chemically or biologically produced banks of peptides. Selected peptides would then act as the pharmacore.

Thus, one can design drugs which have, e.g., improved activity or stability or which act as modulators (e.g., inhibitors, agonists, antagonists) of MTSP7 protein activity, and are useful in the methods, particularly the methods for diagnosis, treatment, prevention, and screening of a neoplastic disease. By virtue of the availability of cloned MTSP7 protein sequences, sufficient amounts of the MTSP7 protein polypeptide can be made available to perform such analytical studies as X-ray crystallography. In addition, the knowledge of the amino acid sequence of an MTSP7 protein or the protease domain thereof, e.g., the protease domain encoded by the amino acid sequence of SEQ ID NO: 2,

can provide guidance on computer modeling techniques in place of, or in addition to, X-ray crystallography.

Methods of identifying peptides and peptide mimetics that bind to MTSP7 proteins

Peptides having a binding affinity to the MTSP7 protein polypeptides provided herein (*e.g.*, an MTSP7 protein or a polypeptide having a protease domain of an MTSP7 protein) can be readily identified, for example, by random peptide diversity generating systems coupled with an affinity enrichment process. Specifically, random peptide diversity generating systems include the "peptides on plasmids" system (see, *e.g.*, U.S. Patent Nos. 5,270,170 and 5,338,665); the "peptides on phage" system (see, *e.g.*, U.S. Patent No. 6,121,238 and Cwirla,*et al.* (1990) *Proc. Natl. Acad. Sci. U.S.A. 87*:6378-6382); the "polysome system;" the "encoded synthetic library (ESL)" system; and the "very large scale immobilized polymer synthesis" system (see, *e.g.*, U.S. Patent No. 6,121,238; and Dower *et al.* (1991) *An. Rep. Med. Chem. 26*:271-280

For example, using the procedures described above, random peptides can generally be designed to have a defined number of amino acid residues in length (*e.g.*, 12). To generate the collection of oligonucleotides encoding the random peptides, the codon motif (NNK)x, where N is nucleotide A, C, G, or T (equimolar; depending on the methodology employed, other nucleotides can be employed), K is G or T (equimolar), and x is an integer corresponding to the number of amino acids in the peptide (*e.g.*, 12) can be used to specify any one of the 32 possible codons resulting from the NNK motif: 1 for each of 12 amino acids, 2 for each of 5 amino acids, 3 for each of 3 amino acids, and only one of the three stop codons. Thus, the NNK motif encodes all of the amino acids, encodes only one stop codon, and reduces codon bias.

The random peptides can be presented, for example, either on the surface of a phage particle, as part of a fusion protein containing either

the pIII or the pVIII coat protein of a phage fd derivative (peptides on phage) or as a fusion protein with the LacI peptide fusion protein bound to a plasmid (peptides on plasmids). The phage or plasmids, including the DNA encoding the peptides, can be identified and isolated by an affinity enrichment process using immobilized MTSP7 protein polypeptide having a protease domain. The affinity enrichment process, sometimes called "panning," typically involves multiple rounds of incubating the phage, plasmids, or polysomes with the immobilized MTSP7 protein polypeptide, collecting the phage, plasmids, or polysomes that bind to the MTSP7 protein polypeptide (along with the accompanying DNA or mRNA), and producing more of the phage or plasmids (along with the accompanying LacI-peptide fusion protein) collected.

Characteristics of peptides and peptide mimetics

Among the peptides, polypeptides and peptide mimetics for therapeutic application are those of having molecular weights from about 250 to about 8,000 daltons. If such peptides are oligomerized, dimerized and/or derivatized with a hydrophilic polymer (*e.g.*, to increase the affinity and/or activity of the compounds), the molecular weights of such peptides can be substantially greater and can range anywhere from about 500 to about 120,000 daltons, generally from about 8,000 to about 80,000 daltons. Such peptides can contain 9 or more amino acids that are naturally occurring or synthetic (non-naturally occurring) amino acids. One skilled in the art can determine the affinity and molecular weight of the peptides and peptide mimetics suitable for therapeutic and/or diagnostic purposes (*e.g.*, see Dower *et al.*, U.S. Patent No. 6,121,238).

The peptides can be covalently attached to one or more of a variety of hydrophilic polymers. Suitable hydrophilic polymers include, but are not limited to, polyalkylethers as exemplified by polyethylene glycol and polypropylene glycol, polylactic acid, polyglycolic acid, polyoxyalkenes, polyvinylalcohol, polyvinylpyrrolidone, cellulose and cellulose derivatives, dextran and dextran derivatives. When the peptide compounds are

derivatized with such polymers, their solubility and circulation half-lives can be increased with little, if any, diminishment in their binding activity. The peptide compounds can be dimerized and each of the dimeric subunits can be covalently attached to a hydrophilic polymer. The peptide compounds can be PEGylated, i.e., covalently attached to polyethylene glycol (PEG).

6. Methods of preparing peptides and peptide mimetics

Peptides that bind to MTSP7 proteins can be prepared by classical methods known in the art, for example, by using standard solid phase techniques. The standard methods include exclusive solid phase synthesis, partial solid phase synthesis methods, fragment condensation, classical solution synthesis, and even by recombinant DNA technology (see, *e.g.*, Merrifield (1963) *J. Am. Chem. Soc., 85*:2149, incorporated herein by reference.)

Using the "encoded synthetic library" or "very large scale immobilized polymer synthesis" systems (see, *e.g.*, U.S. Patent No. 5,925,525, and 5,902,723); the minimum size of a peptide with the activity of interest can be determined. In addition all peptides that form the group of peptides that differ from the desired motif (or the minimum size of that motif) in one, two, or more residues can be prepared. This collection of peptides then can be screened ability to bind to the target molecule, *e.g.*, and MTSP7 protein or, generally, the protease domain of an MTSP7 protein. This immobilized polymer synthesis system or other peptide synthesis methods can also be used to synthesize truncation analogs and deletion analogs and combinations of truncation and deletion analogs of the peptide compounds.

These procedures can also be used to synthesize peptides in which amino acids other than the 20 naturally occurring, genetically encoded amino acids are substituted at one, two, or more positions of the peptide. For instance, naphthylalanine can be substituted for tryptophan, facilitating synthesis. Other synthetic amino acids that can be substituted

into the peptides include L-hydroxypropyl, L-3, 4-dihydroxy-phenylalanyl, d amino acids such as L-d-hydroxylysyl and D-d-methylalanyl, L-α-methylalanyl, β amino acids, and isoquinolyl. D amino acids and non-naturally occurring synthetic amino acids can also be incorporated into the peptides (see, *e.g.*, Roberts *et al.* (1983) *Unusual Amino/Acids in Peptide Synthesis, 5*(6):341-449).

The peptides can also be modified by phosphorylation (see, *e.g.*, W. Bannwarth *et al.* (1996) *Biorganic and Medicinal Chemistry Letters, 6*(17):2141-2146), and other methods for making peptide derivatives (see, *e.g.*, Hruby *et al.* (1990) *Biochem. J., 268*(2):249-262). Thus, peptide compounds also serve as a basis to prepare peptide mimetics with similar biological activity.

Those of skill in the art recognize that a variety of techniques are available for constructing peptide mimetics with the same or similar desired biological activity as the corresponding peptide compound but with more favorable activity than the peptide with respect to solubility, stability, and susceptibility to hydrolysis and proteolysis (see, *e.g.*, Morgan *et al.* (1989) *An. Rep. Med. Chem., 24*:243-252). Methods for preparing peptide mimetics modified at the N-terminal amino group, the C-terminal carboxyl group, and/or changing one or more of the amido linkages in the peptide to a non-amido linkage are known to those of skill in the art.

Amino terminus modifications include, but are not limited to, alkylating, acetylating and adding a carbobenzoyl group, forming a succinimide group (see, *e.g.*, Murray *et al.* (1995) *Burger's Medicinal Chemistry and Drug Discovery, 5th ed., Vol. 1,* Manfred E. Wolf, ed., John Wiley and Sons, Inc.). C-terminal modifications include mimetics wherein the C-terminal carboxyl group is replaced by an ester, an amide or modifications to form a cyclic peptide.

In addition to N-terminal and C-terminal modifications, the peptide compounds, including peptide mimetics, can advantageously be modified

with or covalently coupled to one or more of a variety of hydrophilic polymers. It has been found that when peptide compounds are derivatized with a hydrophilic polymer, their solubility and circulation half-lives can be increased and their immunogenicity is masked, with little, if any, diminishment in their binding activity. Suitable nonproteinaceous polymers include, but are not limited to, polyalkylethers as exemplified by polyethylene glycol and polypropylene glycol, polylactic acid, polyglycolic acid, polyoxyalkenes, polyvinylalcohol, polyvinylpyrrolidone, cellulose and cellulose derivatives, dextran and dextran derivatives. Generally, such hydrophilic polymers have an average molecular weight ranging from about 500 to about 100,000 daltons, including from about 2,000 to about 40,000 daltons and, from about 5,000 to about 20,000 daltons. The hydrophilic polymers also can have an average molecular weights of about 5,000 daltons, 10,000 daltons and 20,000 daltons.

Methods for derivatizing peptide compounds or for coupling peptides to such polymers have been described (see, *e.g.*, Zallipsky (1995) *Bioconjugate Chem., 6*:150-165; Monfardini *et al.* (1995) *Bioconjugate Chem., 6*:62-69; U.S. Pat. No. 4,640,835; U.S. Pat. No. 4,496,689; U.S. Pat. No. 4,301,144; U.S. Pat. No. 4,670,417; U.S. Pat. No. 4,791,192; U.S. Pat. No. 4,179,337 and WO 95/34326, all of which are incorporated by reference in their entirety herein).

Other methods for making peptide derivatives are described, for example, in Hruby *et al.* (1990), *Biochem J., 268*(2):249-262, which is incorporated herein by reference. Thus, the peptide compounds also serve as structural models for non-peptidic compounds with similar biological activity. Those of skill in the art recognize that a variety of techniques are available for constructing compounds with the same or similar desired biological activity as a particular peptide compound but with more favorable activity with respect to solubility, stability, and susceptibility to hydrolysis and proteolysis (see, *e.g.*, Morgan *et al.* (1989) *An. Rep. Med. Chem., 24*:243-252, incorporated herein by

reference). These techniques include replacing the peptide backbone with a backbone composed of phosphonates, amidates, carbamates, sulfonamides, secondary amines, and N-methylamino acids.

Peptide compounds can exist in a cyclized form with an intramolecular disulfide bond between the thiol groups of the cysteines. Alternatively, an intermolecular disulfide bond between the thiol groups of the cysteines can be produced to yield a dimeric (or higher oligomeric) compound. One or more of the cysteine residues can also be substituted with a homocysteine.

I. CONJUGATES

A conjugate, containing: a) a single chain protease domain (or proteolytically active portion thereof) of an MTSP7 protein or a full length zymogen, activated form thereof, or two or single chain protease domain thereof; and b) a targeting agent linked to the MTSP7 protein directly or via a linker, wherein the agent facilitates: i) affinity isolation or purification of the conjugate; ii) attachment of the conjugate to a surface; iii) detection of the conjugate; or iv) targeted delivery to a selected tissue or cell, is provided herein. The conjugate can be a chemical conjugate or a fusion protein mixture thereof.

The targeting agent is generally a protein or peptide fragment, such as a tissue specific or tumor specific monoclonal antibody or growth factor or fragment thereof linked either directly or via a linker to an MTSP7 protein or a protease domain thereof. The targeting agent can also be a protein or peptide fragment that contains a protein binding sequence, a nucleic acid binding sequence, a lipid binding sequence, a polysaccharide binding sequence, or a metal binding sequence, or a linker for attachment to a solid support. In a particular embodiment, the conjugate contains a) the MTSP7 or portion thereof, as described herein; and b) a targeting agent linked to the MTSP7 protein directly or via a linker.

Conjugates, such as fusion proteins and chemical conjugates, of the MTSP7 protein with a protein or peptide fragment (or plurality thereof) that functions, for example, to facilitate affinity isolation or purification of the MTSP7 protein domain, attachment of the MTSP7 protein domain to a surface, or detection of the MTSP7 protein domain are provided. The conjugates can be produced by chemical conjugation, such as via thiol linkages, but are generally produced by recombinant means as fusion proteins. In the fusion protein, the peptide or fragment thereof is linked to either the N-terminus or C-terminus of the MTSP7 protein domain. In chemical conjugates the peptide or fragment thereof can be linked anywhere that conjugation can be effected, and there can be a plurality of such peptides or fragments linked to a single MTSP7 protein domain or to a plurality thereof.

The targeting agent is for *in vitro* or *in vivo* delivery to a cell or tissue, and includes agents such as cell or tissue-specific antibodies, growth factors and other factors that bind to moieties expressed on specific cells; and other cell or tissue specific agents that promote directed delivery of a linked protein. Generally the targeting agent is one that specifically delivers the MTSP7 protein to selected cells by interaction with a cell surface protein and internalization of conjugate or MTSP7 protein portion thereof.

These conjugates are used in a variety of methods and are particularly suited for use in methods of activation of prodrugs, such as prodrugs that, upon cleavage by the particular MTSP7 protein are cytotoxic. The prodrugs are administered prior to simultaneously with or subsequently to the conjugate. Upon delivery to the targeted cells, the protease activates the prodrug, which then exhibits is therapeutic effect, such as a cytotoxic effect.

1. Conjugation

Conjugates with linked MTSP7 protein domains can be prepared either by chemical conjugation, recombinant DNA technology, or combinations of recombinant expression and chemical conjugation. The MTSP7 protein domains and the targeting agent can be linked in any orientation and more than one targeting agents and/or MTSP7 protein domains can be present in a conjugate.

a. Fusion proteins

Fusion proteins are proved herein. A fusion protein contains: a) one or a plurality of domains of an MTSP7 proteins and b) a targeting agent. The fusion proteins are generally produced by recombinant expression of nucleic acids that encode the fusion protein.

b. Chemical conjugation

To effect chemical conjugation herein, the MTSP7 protein domain is linked via one or more selected linkers or directly to the targeting agent. Chemical conjugation must be used if the targeted agent is other than a peptide or protein, such a nucleic acid or a non-peptide drug. Any means known to those of skill in the art for chemically conjugating selected moieties can be used.

2. Linkers

Linkers for two purposes are contemplated herein. The conjugates can include one or more linkers between the MTSP7 protein portion and the targeting agent. Additionally, linkers are used for facilitating or enhancing immobilization of an MTSP7 protein or portion thereof on a solid support, such as a microtiter plate, silicon or silicon-coated chip, glass or plastic support, such as for high throughput solid phase screening protocols.

Any linker known to those of skill in the art for preparation of conjugates can be used herein. These linkers are typically used in the preparation of chemical conjugates; peptide linkers can be incorporated into fusion proteins.

Linkers can be any moiety suitable to associate a domain of MTSP7 protein and a targeting agent. Such linkers and linkages include, but are not limited to, peptidic linkages, amino acid and peptide linkages, typically containing between one and about 60 amino acids, more generally between about 10 and 30 amino acids, chemical linkers, such as heterobifunctional cleavable cross-linkers, including but are not limited to, N-succinimidyl (4-iodoacetyl)-aminobenzoate, sulfosuccinimydil (4-iodoacetyl)-aminobenzoate, 4-succinimidyl-oxycarbonyl-a- (2-pyridyldithio)toluene, sulfosuccinimidyl-6- [a-methyl-a-(pyridyldithiol)-toluamido] hexanoate, N-succinimidyl-3-(-2-pyridyldithio) - proprionate, succinimidyl 6[3(-(-2-pyridyldithio)-proprionamido] hexanoate, sulfosuccinimidyl 6[3(-(-2-pyridyldithio)-propionamido] hexanoate, 3-(2-pyridyldithio)-propionyl hydrazide, Ellman's reagent, dichlorotriazinic acid, and S-(2-thiopyridyl)-L-cysteine. Other linkers include, but are not limited to peptides and other moieties that reduce stearic hindrance between the domain of MTSP7 protein and the targeting agent, intracellular enzyme substrates, linkers that increase the flexibility of the conjugate, linkers that increase the solubility of the conjugate, linkers that increase the serum stability of the conjugate, photocleavable linkers and acid cleavable linkers.

Other exemplary linkers and linkages that are suitable for chemically linked conjugates include, but are not limited to, disulfide bonds, thioether bonds, hindered disulfide bonds, and covalent bonds between free reactive groups, such as amine and thiol groups. These bonds are produced using heterobifunctional reagents to produce reactive thiol groups on one or both of the polypeptides and then reacting the thiol groups on one polypeptide with reactive thiol groups or amine groups to

which reactive maleimido groups or thiol groups can be attached on the other. Other linkers include, acid cleavable linkers, such as bismaleimideothoxy propane, acid labile-transferrin conjugates and adipic acid diihydrazide, that would be cleaved in more acidic intracellular compartments; cross linkers that are cleaved upon exposure to UV or visible light and linkers, such as the various domains, such as C_H1, C_H2, and C_H3, from the constant region of human IgG_1 (see, Batra *et al. Molecular Immunol.*, 30:379-386 (1993)). In some embodiments, several linkers can be included in order to take advantage of desired properties of each linker.

Chemical linkers and peptide linkers can be inserted by covalently coupling the linker to the domain of MTSP7 protein and the targeting agent. The heterobifunctional agents, described below, can be used to effect such covalent coupling. Peptide linkers can also be linked by expressing DNA encoding the linker and TA, linker and targeted agent, or linker, targeted agent and TA as a fusion protein. Flexible linkers and linkers that increase solubility of the conjugates are contemplated for use, either alone or with other linkers are also contemplated herein.

a) Acid cleavable, photocleavable and heat sensitive linkers

Acid cleavable linkers, photocleavable and heat sensitive linkers can also be used, particularly where it can be necessary to cleave the domain of MTSP7 protein to permit it to be more readily accessible to reaction. Acid cleavable linkers include, but are not limited to, bismaleimideothoxy propane; and adipic acid dihydrazide linkers (see, *e.g.*, Fattom *et al.* (1992) *Infection & Immun. 60*:584-589) and acid labile transferrin conjugates that contain a sufficient portion of transferrin to permit entry into the intracellular transferrin cycling pathway (see, *e.g.*, Welhöner *et al.* (1991) *J. Biol. Chem. 266*:4309-4314).

Photocleavable linkers are linkers that are cleaved upon exposure to light (see, *e.g.*, Goldmacher *et al.* (1992) *Bioconj. Chem. 3*:104-107, which linkers are herein incorporated by reference), thereby releasing the targeted agent upon exposure to light. Photocleavable linkers that are cleaved upon exposure to light are known (see, *e.g.*, Hazum *et al.* (1981) in *Pept., Proc. Eur. Pept. Symp.*, 16th, Brunfeldt, K (Ed), pp. 105-110, which describes the use of a nitrobenzyl group as a photocleavable protective group for cysteine; Yen *et al.* (1989) *Makromol. Chem 190*:69-82, which describes water soluble photocleavable copolymers, including hydroxypropylmethacrylamide copolymer, glycine copolymer, fluorescein copolymer and methylrhodamine copolymer; Goldmacher *et al.* (1992) *Bioconj. Chem. 3*:104-107, which describes a cross-linker and reagent that undergoes photolytic degradation upon exposure to near UV light (350 nm); and Senter *et al.* (1985) *Photochem. Photobiol 42*:231-237, which describes nitrobenzyloxycarbonyl chloride cross linking reagents that produce photocleavable linkages), thereby releasing the targeted agent upon exposure to light. Such linkers would have particular use in treating dermatological or ophthalmic conditions that can be exposed to light using fiber optics. After administration of the conjugate, the eye or skin or other body part can be exposed to light, resulting in release of the targeted moiety from the conjugate. Such photocleavable linkers are useful in connection with diagnostic protocols in which it is desirable to remove the targeting agent to permit rapid clearance from the body of the animal.

b) Other linkers for chemical conjugation

Other linkers, include trityl linkers, particularly, derivatized trityl groups to generate a genus of conjugates that provide for release of therapeutic agents at various degrees of acidity or alkalinity. The flexibility thus afforded by the ability to preselect the pH range at which the therapeutic agent will be released allows selection of a linker based on the known physiological differences between tissues in need of

delivery of a therapeutic agent (see, *e.g.*, U.S. Patent No. 5,612,474). For example, the acidity of tumor tissues appears to be lower than that of normal tissues.

c) Peptide linkers

The linker moieties can be peptides. Peptide linkers can be employed in fusion proteins and also in chemically linked conjugates. The peptide typically has from about 2 to about 60 amino acid residues, for example from about 5 to about 40, or from about 10 to about 30 amino acid residues. The length selected will depend upon factors, such as the use for which the linker is included.

Peptide linkers are advantageous when the targeting agent is proteinaceous. For example, the linker moiety can be a flexible spacer amino acid sequence, such as those known in single-chain antibody research. Examples of such known linker moieties include, but are not limited to, peptides, such as $(Gly_mSer)_n$ and $(Ser_mGly)_n$, in which n is 1 to 6, generally 1 to 4 or 2 to 4, and m is 1 to 6, generally 1 to 4 or 2 to 4, enzyme cleavable linkers and others.

Additional linking moieties are known (see, *e.g.*, Huston *et al.*, *Proc. Natl. Acad. Sci. U.S.A. 85*:5879-5883, 1988; Whitlow, M., *et al.*, *Protein Engineering 6*:989-995, 1993; Newton *et al.*, *Biochemistry 35*:545-553, 1996; A. J. Cumber *et al.*, *Bioconj. Chem. 3*:397-401, 1992; Ladurner *et al.*, *J. Mol. Biol. 273*:330-337, 1997; and U.S. Patent. No. 4,894,443). In some embodiments, several linkers can be included in order to take advantage of desired properties of each linker.

3. Targeting agents

Any agent that facilitates detection, immobilization, or purification of the conjugate is contemplated for use herein. For chemical conjugates any moiety that has such properties is contemplated; for fusion proteins, the targeting agent is a protein, peptide or fragment thereof that sufficient to effects the targeting activity. Generally targeting agents are those that deliver the MTSP7 protein or portion thereof to selected cells and tissues.

Such agents include tumor specific monoclonal antibodies and portions thereof, growth factors, such as FGF, EGF, PDGF, VEGF, cytokines, including chemokines, and other such agents.

4. Nucleic acids, plasmids and cells

Isolated nucleic acid fragments encoding fusion proteins are provided. The nucleic acid fragment that encodes the fusion protein includes: a) nucleic acid encoding a protease domain of an MTSP7 protein; and b) nucleic acid encoding a protein, peptide or effective fragment thereof that facilitates: i) affinity isolation or purification of the fusion protein; ii) attachment of the fusion protein to a surface; or iii) detection of the fusion protein. Generally, the nucleic acid is DNA.

Plasmids for replication and vectors for expression that contain the above nucleic acid fragments are also provided. Cells containing the plasmids and vectors are also provided. The cells can be any suitable host including, but are not limited to, bacterial cells, yeast cells, fungal cells, plant cells, insect cell and animal cells. The nucleic acids, plasmids, and cells containing the plasmids can be prepared according to methods known in the art including any described herein.

Also provided are methods for producing the above fusion proteins. An exemplary method includes the steps of growing, i.e. culturing the cells so that the proliferate, cells containing a plasmid encoding the fusion protein under conditions whereby the fusion protein is expressed by the cell, and recovering the expressed fusion protein. Methods for expressing and recovering recombinant proteins are well known in the art (*See generally, Current Protocols in Molecular Biology* (1998) § 16, John Wiley & Sons, Inc.) and such methods can be used for expressing and recovering the expressed fusion proteins. Typically, the recombinant expression and recovery methods described herein can be used.

The recovered fusion proteins can be isolated or purified by methods known in the art such as centrifugation, filtration, chromatograph, electrophoresis, immunoprecipitation, or by a combination

thereof (*See generally, Current Protocols in Molecular Biology* (1998) § 10, John Wiley & Sons, Inc.). For example, the recovered fusion protein is isolated or purified through affinity binding between the protein or peptide fragment of the fusion protein and an affinity binding moiety. As discussed in the above sections regarding the construction of the fusion proteins, any affinity binding pairs can be constructed and used in the isolation or purification of the fusion proteins. For example, the affinity binding pairs can be protein binding sequences/protein, DNA binding sequences/DNA sequences, RNA binding sequences/RNA sequences, lipid binding sequences/lipid, polysaccharide binding sequences/polysaccharide, or metal binding sequences/metal.

5. Immobilization and supports or substrates therefor

In certain embodiments, where the targeting agents are designed for linkage to surfaces, the MTSP7 protein can be attached by linkage such as ionic or covalent, non-covalent or other chemical interaction, to a surface of a support or matrix material. Immobilization can be effected directly or via a linker. The MTSP7 protein can be immobilized on any suitable support, including, but are not limited to, silicon chips, and other supports described herein and known to those of skill in the art. A plurality of MTSP7 protein or protease domains thereof can be attached to a support, such as an array (*i.e.*, a pattern of two or more) of conjugates on the surface of a silicon chip or other chip for use in high throughput protocols and formats.

It is also noted that the domains of the MTSP7 protein can be linked directly to the surface or via a linker without a targeting agent linked thereto. Hence chips containing arrays of the domains of the MTSP7 protein.

The matrix material or solid supports contemplated herein are generally any of the insoluble materials known to those of skill in the art to immobilize ligands and other molecules, and are those that used in many chemical syntheses and separations. Such supports are used, for

example, in affinity chromatography, in the immobilization of biologically active materials, and during chemical syntheses of biomolecules, including proteins, amino acids and other organic molecules and polymers. The preparation of and use of supports is well known to those of skill in this art; there are many such materials and preparations thereof known. For example, naturally-occurring support materials, such as agarose and cellulose, can be isolated from their respective sources, and processed according to known protocols, and synthetic materials can be prepared in accord with known protocols.

The supports are typically insoluble materials that are solid, porous, deformable, or hard, and have any required structure and geometry, including, but not limited to: beads, pellets, disks, capillaries, hollow fibers, needles, solid fibers, random shapes, thin films and membranes. Thus, the item can be fabricated from the matrix material or combined with it, such as by coating all or part of the surface or impregnating particles.

Typically, when the matrix is particulate, the particles are at least about 10-2000 μM, but can be smaller or larger, depending upon the selected application. Selection of the matrices will be governed, at least in part, by their physical and chemical properties, such as solubility, functional groups, mechanical stability, surface area swelling propensity, hydrophobic or hydrophilic properties and intended use.

If necessary, the support matrix material can be treated to contain an appropriate reactive moiety. In some cases, the support matrix material already containing the reactive moiety can be obtained commercially. The support matrix material containing the reactive moiety can thereby serve as the matrix support upon which molecules are linked. Materials containing reactive surface moieties such as amino silane linkages, hydroxyl linkages or carboxysilane linkages can be produced by well established surface chemistry techniques involving silanization reactions, or the like. Examples of these materials are those having surface silicon oxide moieties, covalently linked to gamma-aminopropyl-

silane, and other organic moieties; N-[3-(triethyoxysilyl)propyl]phthelamic acid; and bis-(2-hydroxyethyl)aminopropyltriethoxysilane. Exemplary of readily available materials containing amino group reactive functionalities, include, but are not limited to, para-aminophenyltriethyoxysilane. Also derivatized polystyrenes and other such polymers are well known and readily available to those of skill in this art (*e.g.*, the Tentagel® Resins are available with a multitude of functional groups, and are sold by Rapp Polymere, Tubingen, Germany; see, U.S. Patent No. 4,908,405 and U.S. Patent No. 5,292,814; *see, also* Butz et al., *Peptide Res.*, 7:20-23 (1994); and Kleine et al., *Immunobiol.*, 190:53-66 (1994)).

These matrix materials include any material that can act as a support matrix for attachment of the molecules of interest. Such materials are known to those of skill in this art, and include those that are used as a support matrix. These materials include, but are not limited to, inorganics, natural polymers, and synthetic polymers, including, but are not limited to: cellulose, cellulose derivatives, acrylic resins, glass, silica gels, polystyrene, gelatin, polyvinyl pyrrolidone, co-polymers of vinyl and acrylamide, polystyrene cross-linked with divinylbenzene and others (*see*, Merrifield, *Biochemistry*, 3:1385-1390 (1964)), polyacrylamides, latex gels, polystyrene, dextran, polyacrylamides, rubber, silicon, plastics, nitrocellulose, celluloses, natural sponges. Of particular interest herein, are highly porous glasses (*see, e.g.*, U.S. Patent No. 4,244,721) and others prepared by mixing a borosilicate, alcohol and water.

Synthetic supports include, but are not limited to: acrylamides, dextran-derivatives and dextran co-polymers, agarose-polyacrylamide blends, other polymers and co-polymers with various functional groups, methacrylate derivatives and co-polymers, polystyrene and polystyrene copolymers (*see, e.g.*, Merrifield, *Biochemistry*, 3:1385-1390 (1964); Berg et al., in *Innovation Perspect. Solid Phase Synth. Collect. Pap.*, Int. Symp., 1st, Epton, Roger (Ed), pp. 453-459 (1990); Berg et al., *Pept., Proc. Eur. Pept. Symp.*, 20th, Jung, G. et al. (Eds), pp. 196-198 (1989);

Berg et al., *J. Am. Chem. Soc.*, 111:8024-8026 (1989); Kent et al., *Isr. J. Chem.*, 17:243-247 (1979); Kent et al., *J. Org. Chem.*, 43:2845-2852 (1978); Mitchell et al., *Tetrahedron Lett.*, 42:3795-3798 (1976); U.S. Patent No. 4,507,230; U.S. Patent No. 4,006,117; and U.S. Patent No. 5,389,449). Such materials include those made from polymers and co-polymers such as polyvinylalcohols, acrylates and acrylic acids such as polyethylene-co-acrylic acid, polyethylene-co-methacrylic acid, polyethylene-co-ethylacrylate, polyethylene-co-methyl acrylate, polypropylene-co-acrylic acid, polypropylene-co-methyl-acrylic acid, polypropylene-co-ethylacrylate, polypropylene-co-methyl acrylate, polyethylene-co-vinyl acetate, polypropylene-co-vinyl acetate, and those containing acid anhydride groups such as polyethylene-co-maleic anhydride and polypropylene-co-maleic anhydride. Liposomes have also been used as solid supports for affinity purifications (Powell et al. *Biotechnol. Bioeng.*, 33:173 (1989)).

Numerous methods have been developed for the immobilization of proteins and other biomolecules onto solid or liquid supports (*see, e.g.*, Mosbach, *Methods in Enzymology*, 44 (1976); Weetall, *Immobilized Enzymes, Antigens, Antibodies, and Peptides*, (1975); Kennedy et al., *Solid Phase Biochemistry, Analytical and Synthetic Aspects*, Scouten, ed., pp. 253-391 (1983); *see, generally*, Affinity Techniques. Enzyme Purification: *Part B. Methods in Enzymology*, Vol. 34, ed. W. B. Jakoby, M. Wilchek, Acad. Press, N.Y. (1974); and Immobilized Biochemicals and Affinity Chromatography, *Advances in Experimental Medicine and Biology*, vol. 42, ed. R. Dunlap, Plenum Press, N.Y. (1974)).

Among the most commonly used methods are absorption and adsorption or covalent binding to the support, either directly or via a linker, such as the numerous disulfide linkages, thioether bonds, hindered disulfide bonds, and covalent bonds between free reactive groups, such as amine and thiol groups, known to those of skill in art (*see, e.g.*, the PIERCE CATALOG, ImmunoTechnology Catalog & Handbook, 1992-1993, which describes the preparation of and use of such reagents and provides

a commercial source for such reagents; Wong, *Chemistry of Protein Conjugation and Cross Linking*, CRC Press (1993); *see also* DeWitt et al., *Proc. Natl. Acad. Sci. U.S.A.*, 90:6909 (1993); Zuckermann et al., *J. Am. Chem. Soc.*, 114:10646 (1992); Kurth et al., *J. Am. Chem. Soc.*, 116:2661 (1994); Ellman et al., *Proc. Natl. Acad. Sci. U.S.A.*, 91:4708 (1994); Sucholeiki, *Tetrahedron Lttrs.*, 35:7307 (1994); Su-Sun Wang, *J. Org. Chem.*, 41:3258 (1976); Padwa et al., *J. Org. Chem.*, 41:3550 (1971); and Vedejs et al., *J. Org. Chem.*, 49:575 (1984), which describe photosensitive linkers).

To effect immobilization, a composition containing the protein or other biomolecule is contacted with a support material such as alumina, carbon, an ion-exchange resin, cellulose, glass or a ceramic. Fluorocarbon polymers have been used as supports to which biomolecules have been attached by adsorption (*see*, U.S. Patent No. 3,843,443; Published International PCT Application WO/86 03840).

J. Prognosis and diagnosis

MTSP7 protein proteins, domains, analogs, and derivatives thereof, and encoding nucleic acids (and sequences complementary thereto), and anti-MTSP7 protein antibodies, can be used in diagnostics. Such molecules can be used in assays, such as immunoassays, to detect, prognose, diagnose, or monitor various conditions, diseases, and disorders affecting MTSP7 protein expression, or monitor the treatment thereof. For purposes herein, the presence of MTSP7s in body fluids or tumor tissues are of particular interest.

In particular, such an immunoassay is carried out by a method including contacting a sample derived from a patient with an anti-MTSP7 protein antibody under conditions such that specific binding can occur, and detecting or measuring the amount of any specific binding by the antibody. In a specific aspect, such binding of antibody, in tissue sections, can be used to detect aberrant MTSP7 protein localization or aberrant (*e.g.*, increased, decreased or absent) levels of MTSP7 protein.

In a specific embodiment, antibody to MTSP7 protein can be used to assay in a patient tissue or serum sample for the presence of MTSP7 protein where an aberrant level of MTSP7 protein is an indication of a diseased condition.

The immunoassays which can be used include but are not limited to competitive and non-competitive assay systems using techniques such as western blots, radioimmunoassays, ELISA (enzyme linked immunosorbent assay), "sandwich" immunoassays, immunoprecipitation assays, precipitin reactions, gel diffusion precipitin reactions, immunodiffusion assays, agglutination assays, complement-fixation assays, immunoradiometric assays, fluorescent immunoassays and protein A immunoassays.

MTSP7 protein genes and related nucleic acid sequences and subsequences, including complementary sequences, can also be used in hybridization assays. MTSP7 protein nucleic acid sequences, or subsequences thereof containing about at least 8 nucleotides, 14 or 16 or 30 or more continugous nucleotides, can be used as hybridization probes. Hybridization assays can be used to detect, prognose, diagnose, or monitor conditions, disorders, or disease states associated with aberrant changes in MTSP7 protein expression and/or activity as described herein. In particular, such a hybridization assay is carried out by a method by contacting a sample containing nucleic acid with a nucleic acid probe capable of hybridizing to MTSP7 protein encoding DNA or RNA, under conditions such that hybridization can occur, and detecting or measuring any resulting hybridization.

In a specific embodiment, a method of diagnosing a disease or disorder characterized by detecting an aberrant level of an MTSP7 protein in a subject is provided herein by measuring the level of the DNA, RNA, protein or functional activity of the MTSP7 protein in a sample derived from the subject, wherein an increase or decrease in the level of the DNA, RNA, protein or functional activity of the MTSP7 protein, relative to the

level of the DNA, RNA, protein or functional activity found in an analogous sample not having the disease or disorder indicates the presence of the disease or disorder in the subject.

Kits for diagnostic use are also provided, that contain in one or more containers an anti-MTSP7 protein antibody, and, optionally, a labeled binding partner to the antibody. Alternatively, the anti-MTSP7 protein antibody can be labeled (with a detectable marker, *e.g.*, a chemiluminescent, enzymatic, fluorescent, or radioactive moiety). A kit is also provided that includes in one or more containers a nucleic acid probe capable of hybridizing to MTSP protein-encoding RNA. In a specific embodiment, a kit can comprise in one or more containers a pair of primers (*e.g.*, each in the size range of 6-30 nucleotides) that are capable of priming amplification [*e.g.*, by polymerase chain reaction (see *e.g.*, Innis et al., 1990, PCR Protocols, Academic Press, Inc., San Diego, CA), ligase chain reaction (see EP 320,308) use of Qβ replicase, cyclic probe reaction, or other methods known in the art under appropriate reaction conditions of at least a portion of an MTSP protein-encoding nucleic acid. A kit can optionally further comprise in a container a predetermined amount of a purified MTSP7 protein or nucleic acid, *e.g.*, for use as a standard or control.

K. PHARMACEUTICAL COMPOSITIONS AND MODES OF ADMINISTRATION

1. Components of the compositions

Pharmaceutical compositions containing the identified compounds that modulate the activity of an MTSP7 protein are provided herein. Also provided are combinations of a compound that modulates the activity of an MTSP7 protein and another treatment or compound for treatment of a neoplastic disorder, such as a chemotherapeutic compound.

The MTSP7 protein modulator and the anti-tumor agent can be packaged as separate compositions for administration together or sequentially or intermittently. Alternatively, they can provided as

a single composition for administration or as two compositions for administration as a single composition. The combinations can be packaged as kits.

a. MTSP7 protein inhibitors

Any MTSP7 protein inhibitors, including those described herein when used alone or in combination with other compounds, that can alleviate, reduce, ameliorate, prevent, or place or maintain in a state of remission of clinical symptoms or diagnostic markers associated with neoplastic diseases, including undesired and/or uncontrolled angiogenesis, can be used in the present combinations.

In one embodiment, the MTSP7 protein inhibitor is an antibody or fragment thereof that specifically reacts with an MTSP7 protein or the protease domain thereof, an inhibitor of the MTSP7 protein production, an inhibitor of the epithelial MTSP7 protein membrane-localization, or any inhibitor of the expression of or, especially, the activity of an MTSP7 protein.

b. Anti-angiogenic agents and anti-tumor agents

Any anti-angiogenic agents and anti-tumor agents, including those described herein, when used alone or in combination with other compounds, that can alleviate, reduce, ameliorate, prevent, or place or maintain in a state of remission of clinical symptoms or diagnostic markers associated with undesired and/or uncontrolled angiogenesis and/or tumor growth and metastasis, particularly solid neoplasms, vascular malformations and cardiovascular disorders, chronic inflammatory diseases and aberrant wound repairs, circulatory disorders, crest syndromes, dermatological disorders, or ocular disorders, can be used in the combinations. Also contemplated are anti-tumor agents for use in combination with an inhibitor of an MTSP7 protein.

c. **Anti-tumor agents and anti-angiogenic agents**

The compounds identified by the methods provided herein or provided herein can be used in combination with anti-tumor agents and/or anti-angiogenesis agents.

2. Formulations and route of administration

The compounds herein and agents can be formulated as pharmaceutical compositions, generally for single dosage administration. The concentrations of the compounds in the formulations are effective for delivery of an amount, upon administration, that is effective for the intended treatment. Typically, the compositions are formulated for single dosage administration. To formulate a composition, the weight fraction of a compound or mixture thereof is dissolved, suspended, dispersed or otherwise mixed in a selected vehicle at an effective concentration such that the treated condition is relieved or ameliorated. Pharmaceutical carriers or vehicles suitable for administration of the compounds provided herein include any such carriers known to those skilled in the art to be suitable for the particular mode of administration.

In addition, the compounds can be formulated as the sole pharmaceutically active ingredient in the composition or can be combined with other active ingredients. Liposomal suspensions, including tissue-targeted liposomes, can also be suitable as pharmaceutically acceptable carriers. These can be prepared according to methods known to those skilled in the art. For example, liposome formulations can be prepared as described in U.S. Patent No. 4,522,811.

The active compound is included in the pharmaceutically acceptable carrier in an amount sufficient to exert a therapeutically useful effect in the absence of undesirable side effects on the patient treated. The therapeutically effective concentration can be determined empirically by testing the compounds in known in vitro and in vivo systems, such as the assays provided herein.

The concentration of active compound in the drug composition will depend on absorption, inactivation and excretion rates of the active compound, the physicochemical characteristics of the compound, the dosage schedule, and amount administered as well as other factors known to those of skill in the art.

Typically a therapeutically effective dosage is contemplated. The amounts administered can be on the order of 0.001 to 1 mg/ml, including 0.005-0.05 mg/ml or about 0.01 mg/ml, of blood volume. Pharmaceutical dosage unit forms are prepared to provide from about 1 mg to about 1000 mg, including 10 to about 500 mg, and generally about 25-75 mg of the essential active ingredient or a combination of essential ingredients per dosage unit form. The precise dosage can be empirically determined.

The active ingredient can be administered at once, or can be divided into a number of smaller doses to be administered at intervals of time. It is understood that the precise dosage and duration of treatment is a function of the disease being treated and can be determined empirically using known testing protocols or by extrapolation from in vivo or in vitro test data. It is to be noted that concentrations and dosage values can also vary with the severity of the condition to be alleviated. It is to be further understood that for any particular subject, specific dosage regimens should be adjusted over time according to the individual need and the professional judgment of the person administering or supervising the administration of the compositions, and that the concentration ranges set forth herein are exemplary only and are not intended to limit the scope or use of the claimed compositions and combinations containing them.

Exemplary pharmaceutically acceptable derivatives include acids, salts, esters, hydrates, solvates and prodrug forms. The derivative is typically selected such that its pharmacokinetic properties are superior to the corresponding neutral compound.

Thus, effective concentrations or amounts of one or more of the compounds provided herein or pharmaceutically acceptable derivatives thereof are mixed with a suitable pharmaceutical carrier or vehicle for systemic, topical or local administration to form pharmaceutical compositions. Compounds are included in an amount effective for ameliorating or treating the disorder for which treatment is contemplated. The concentration of active compound in the composition will depend on absorption, inactivation, excretion rates of the active compound, the dosage schedule, amount administered, particular formulation as well as other factors known to those of skill in the art.

Solutions or suspensions used for parenteral, intradermal, subcutaneous, or topical application can include any of the following components: a sterile diluent, such as water for injection, saline solution, fixed oil, polyethylene glycol, glycerine, propylene glycol or other synthetic solvent; antimicrobial agents, such as benzyl alcohol and methyl parabens; antioxidants, such as ascorbic acid and sodium bisulfite; chelating agents, such as ethylenediaminetetraacetic acid (EDTA); buffers, such as acetates, citrates and phosphates; and agents for the adjustment of tonicity such as sodium chloride or dextrose. Parenteral preparations can be enclosed in ampules, disposable syringes or single or multiple dose vials made of glass, plastic or other suitable material.

In instances in which the compounds exhibit insufficient solubility, methods for solubilizing compounds can be used. Such methods are known to those of skill in this art, and include, but are not limited to, using cosolvents, such as dimethylsulfoxide (DMSO), using surfactants, such as Tween®, or dissolution in aqueous sodium bicarbonate. Derivatives of the compounds, such as prodrugs of the compounds can also be used in formulating effective pharmaceutical compositions. For ophthalmic indications, the compositions are formulated in an ophthalmically acceptable carrier. For the ophthalmic uses herein local administration typically is effected either by topical administration or by

injection. Time release formulations are also desirable. Typically, the compositions are formulated for single dosage administration, so that a single dose administers an effective amount.

Upon mixing or addition of the compound with the vehicle, the resulting mixture can be a solution, suspension, emulsion or other composition. The form of the resulting mixture depends upon a number of factors, including the intended mode of administration and the solubility of the compound in the selected carrier or vehicle. If necessary, pharmaceutically acceptable salts or other derivatives of the compounds are prepared.

The compound is included in the pharmaceutically acceptable carrier in an amount sufficient to exert a therapeutically useful effect in the absence of undesirable side effects on the patient treated. It is understood that number and degree of side effects depends upon the condition for which the compounds are administered. For example, certain toxic and undesirable side effects are tolerated when treating life-threatening illnesses that would not be tolerated when treating disorders of lesser consequence.

The compounds can also be mixed with other active materials, that do not impair the desired action, or with materials that supplement the desired action known to those of skill in the art. The formulations of the compounds and agents for use herein include those suitable for oral, rectal, topical, inhalational, buccal (*e.g.*, sublingual), parenteral (*e.g.*, subcutaneous, intramuscular, intradermal, or intravenous), transdermal administration or any route. The most suitable route in any given case will depend on the nature and severity of the condition being treated and on the nature of the particular active compound which is being used. The formulations are provided for administration to humans and animals in unit dosage forms, such as tablets, capsules, pills, powders, granules, sterile parenteral solutions or suspensions, and oral solutions or suspensions, and oil-water emulsions containing suitable quantities of the compounds

or pharmaceutically acceptable derivatives thereof. The pharmaceutically therapeutically active compounds and derivatives thereof are typically formulated and administered in unit-dosage forms or multiple-dosage forms. Unit-dose forms as used herein refers to physically discrete units suitable for human and animal subjects and packaged individually as is known in the art. Each unit-dose contains a predetermined quantity of the therapeutically active compound sufficient to produce the desired therapeutic effect, in association with the required pharmaceutical carrier, vehicle or diluent. Examples of unit-dose forms include ampoules and syringes and individually packaged tablets or capsules. Unit-dose forms can be administered in fractions or multiples thereof. A multiple-dose form is a plurality of identical unit-dosage forms packaged in a single container to be administered in segregated unit-dose form. Examples of multiple-dose forms include vials, bottles of tablets or capsules or bottles of pints or gallons. Hence, multiple dose form is a multiple of unit-doses which are not segregated in packaging.

The composition can contain along with the active ingredient: a diluent such as lactose, sucrose, dicalcium phosphate, or carboxymethyl-cellulose; a lubricant, such as magnesium stearate, calcium stearate and talc; and a binder such as starch, natural gums, such as gum acaciagelatin, glucose, molasses, polvinylpyrrolidine, celluloses and derivatives thereof, povidone, crospovidones and other such binders known to those of skill in the art. Liquid pharmaceutically administrable compositions can, for example, be prepared by dissolving, dispersing, or otherwise mixing an active compound as defined above and optional pharmaceutical adjuvants in a carrier, such as, for example, water, saline, aqueous dextrose, glycerol, glycols, ethanol, and the like, to thereby form a solution or suspension. If desired, the pharmaceutical composition to be administered can also contain minor amounts of nontoxic auxiliary substances such as wetting agents, emulsifying agents, or solubilizing agents, pH buffering agents and the like, for example, acetate, sodium

citrate, cyclodextrine derivatives, sorbitan monolaurate, triethanolamine sodium acetate, triethanolamine oleate, and other such agents. Methods of preparing such dosage forms are known, or will be apparent, to those skilled in this art (see, *e.g.*, Remington's Pharmaceutical Sciences, Mack Publishing Company, Easton, Pa., 15th Edition, 1975). The composition or formulation to be administered will contain a quantity of the active compound in an amount sufficient to alleviate the symptoms of the treated subject.

Dosage forms or compositions containing active ingredient in the range of 0.005% to 100% with the balance made up from non-toxic carrier can be prepared. For oral administration, the pharmaceutical compositions can take the form of, for example, tablets or capsules prepared by conventional means with pharmaceutically acceptable excipients such as binding agents (*e.g.*, pregelatinized maize starch, polyvinyl pyrrolidone or hydroxypropyl methylcellulose); fillers (*e.g.*, lactose, microcrystalline cellulose or calcium hydrogen phosphate); lubricants (*e.g.*, magnesium stearate, talc or silica); disintegrants (*e.g.*, potato starch or sodium starch glycolate); or wetting agents (*e.g.*, sodium lauryl sulphate). The tablets can be coated by methods well-known in the art.

The pharmaceutical preparation can also be in liquid form, for example, solutions, syrups or suspensions, or can be presented as a drug product for reconstitution with water or other suitable vehicle before use. Such liquid preparations can be prepared by conventional means with pharmaceutically acceptable additives such as suspending agents (*e.g.*, sorbitol syrup, cellulose derivatives or hydrogenated edible fats); emulsifying agents (*e.g.*, lecithin or acacia); non-aqueous vehicles (*e.g.*, almond oil, oily esters, or fractionated vegetable oils); and preservatives (*e.g.*, methyl or propyl-p-hydroxybenzoates or sorbic acid).

Formulations suitable for rectal administration are generally presented as unit dose suppositories. These can be prepared by admixing

the active compound with one or more conventional solid carriers, for example, cocoa butter, and then shaping the resulting mixture.

Formulations suitable for topical application to the skin or to the eye generally take the form of an ointment, cream, lotion, paste, gel, spray, aerosol and oil. Carriers which can be used include vaseline, lanoline, polyethylene glycols, alcohols, and combinations of two or more thereof. The topical formulations can further advantageously contain 0.05 to 15 percent by weight of thickeners selected from among hydroxypropyl methyl cellulose, methyl cellulose, polyvinylpyrrolidone, polyvinyl alcohol, poly (alkylene glycols), poly/hydroxyalkyl, (meth)acrylates or poly(meth)acrylamides. A topical formulation is often applied by instillation or as an ointment into the conjunctival sac. It can also be used for irrigation or lubrication of the eye, facial sinuses, and external auditory meatus. It can also be injected into the anterior eye chamber and other places. The topical formulations in the liquid state can be also present in a hydrophilic three-dimensional polymer matrix in the form of a strip, contact lens, and the like from which the active components are released.

For administration by inhalation, the compounds for use herein can be delivered in the form of an aerosol spray presentation from pressurized packs or a nebulizer, with the use of a suitable propellant, *e.g.*, dichlorodifluoromethane, trichlorofluoromethane, dichlorotetrafluoroethane, carbon dioxide or other suitable gas. In the case of a pressurized aerosol, the dosage unit can be determined by providing a valve to deliver a metered amount. Capsules and cartridges of, *e.g.*, gelatin, for use in an inhaler or insufflator can be formulated containing a powder mix of the compound and a suitable powder base such as lactose or starch.

Formulations suitable for buccal (sublingual) administration include, for example, lozenges containing the active compound in a flavored base, usually sucrose and acacia or tragacanth; and pastilles containing the

compound in an inert base such as gelatin and glycerin or sucrose and acacia.

The compounds can be formulated for parenteral administration by injection, *e.g.*, by bolus injection or continuous infusion. Formulations for injection can be presented in unit dosage form, *e.g.*, in ampules or in multi-dose containers, with an added preservative. The compositions can be suspensions, solutions or emulsions in oily or aqueous vehicles, and can contain formulatory agents such as suspending, stabilizing and/or dispersing agents. Alternatively, the active ingredient can be in powder form for reconstitution with a suitable vehicle, *e.g.*, sterile pyrogen-free water or other solvents, before use.

Formulations suitable for transdermal administration can be presented as discrete patches adapted to remain in intimate contact with the epidermis of the recipient for a prolonged period of time. Such patches suitably contain the active compound as an optionally buffered aqueous solution of, for example, 0.1 to 0.2 M concentration with respect to the active compound. Formulations suitable for transdermal administration can also be delivered by iontophoresis (*see, e.g.*, Pharmaceutical Research 3 (6), 318 (1986)) and typically take the form of an optionally buffered aqueous solution of the active compound.

The pharmaceutical compositions can also be administered by controlled release means and/or delivery devices (see, *e.g.*, in U.S. Patent Nos. 3,536,809; 3,598,123; 3,630,200; 3,845,770; 3,847,770; 3,916,899; 4,008,719; 4,687,610; 4,769,027; 5,059,595; 5,073,543; 5,120,548; 5,354,566; 5,591,767; 5,639,476; 5,674,533 and 5,733,566).

Desirable blood levels can be maintained by a continuous infusion of the active agent as ascertained by plasma levels. It should be noted that the attending physician would know how to and when to terminate, interrupt or adjust therapy to lower dosage due to toxicity, or bone marrow, liver or kidney dysfunctions. Conversely, the attending physician

would also know how to and when to adjust treatment to higher levels if the clinical response is not adequate (precluding toxic side effects).

The efficacy and/or toxicity of the MTSP7 protein inhibitor(s), alone or in combination with other agents can also be assessed by the methods known in the art (See generally, O'Reilly, *Investigational New Drugs*, 15:5-13 (1997)).

The active compounds or pharmaceutically acceptable derivatives can be prepared with carriers that protect the compound against rapid elimination from the body, such as time release formulations or coatings.

Kits containing the compositions and/or the combinations with instructions for administration thereof are provided. The kit can further include a needle or syringe, generally packaged in sterile form, for injecting the complex, and/or a packaged alcohol pad. Instructions are optionally included for administration of the active agent by a clinician or by the patient.

Finally, the compounds or MTSP7 proteins or protease domains thereof or compositions containing any of the preceding agents can be packaged as articles of manufacture containing packaging material, a compound or suitable derivative thereof provided herein, which is effective for treatment of a diseases or disorders contemplated herein, within the packaging material, and a label that indicates that the compound or a suitable derivative thereof is for treating the diseases or disorders contemplated herein. The label can optionally include the disorders for which the therapy is warranted.

L. METHODS OF TREATMENT

The compounds identified by the methods herein are used for treating or preventing neoplastic diseases in an animal, particularly a mammal, including a human, is provided herein. In one embodiment, the method includes administering to a mammal an effective amount of an inhibitor of an MTSP7 protein, whereby the disease or disorder is treated or prevented. In certain embodiments, the MTSP7 protein inhibitor used in

the treatment or prevention is administered with a pharmaceutically acceptable carrier or excipient. The mammal treated can be a human. The inhibitors provided herein are those identified by the screening assays. In addition, antibodies and antisense nucleic acids or or dsRNA, such as RNAi, are contemplated.

The treatment or prevention method can further include administering an anti-angiogenic treatment or agent or anti-tumor agent simultaneously with, prior to or subsequent to the MTSP7 protein inhibitor, which can be any compound identified that inhibits the activity of an MTSP7 protein, and includes an antibody or a fragment or derivative thereof containing the binding region thereof against the MTSP7 protein, an antisense nucleic acid encoding the MTSP7 protein or dsRNA, such as RNAi,, and a nucleic acid containing at least a portion of a gene encoding the MTSP7 protein into which a heterologous nucleotide sequence has been inserted such that the heterologous sequence inactivates the biological activity of at least a portion of the gene encoding the MTSP7 protein, in which the portion of the gene encoding the MTSP7 protein flanks the heterologous sequence so as to promote homologous recombination with a genomic gene encoding the MTSP7 protein.

1. Antisense treatment

In a specific embodiment, as described hereinabove, MTSP7 protein function is reduced or inhibited by MTSP7 protein antisense nucleic acids, to treat or prevent neoplastic disease. The therapeutic or prophylactic use of nucleic acids of at least six nucleotides that are antisense to a gene or cDNA encoding MTSP7 protein or a portion thereof. An MTSP7 protein "antisense" nucleic acid as used herein refers to a nucleic acid capable of hybridizing to a portion of an MTSP7 protein RNA (generally mRNA) by virtue of some sequence complementarily, and usually under high stringency conditions. The antisense nucleic acid can be complementary to a coding and/or noncoding region of an MTSP7 protein mRNA. Such antisense nucleic acids have utility as therapeutics that

reduce or inhibit MTSP7 protein function, and can be used in the treatment or prevention of disorders as described.

The MTSP7 protein antisense nucleic acids are of at least six nucleotides and are typically oligonucleotides (ranging from 6 to about 150 nucleotides, generally 6 to 50 nucleotides). In specific aspects, the oligonucleotide is at least 10 nucleotides, at least 15 nucleotides, at least 100 nucleotides, or at least 125 nucleotides depending upon the purpose and conditions of use, including desired specificity. The oligonucleotides can be DNA or RNA or chimeric mixtures or derivatives or modified versions thereof, single-stranded or double-stranded. The oligonucleotide can be modified at the base moiety, sugar moiety, or phosphate backbone. The oligonucleotide can include other appending groups such as peptides, or agents facilitating transport across the cell membrane (see, *e.g.*, Letsinger et al., *Proc. Natl. Acad. Sci. U.S.A.* 86:6553-6556 (1989); Lemaitre et al., *Proc. Natl. Acad. Sci. U.S.A.* 84:648-652 (1987); PCT Publication No. WO 88/09810, published December 15, 1988) or blood-brain barrier (see, *e.g.*, PCT Publication No. WO 89/10134, published April 25, 1988), hybridization-triggered cleavage agents (see, *e.g.*, Krol et al., *BioTechniques* 6:958-976 (1988)) or intercalating agents (see, *e.g.*, Zon, *Pharm. Res.* 5:539-549 (1988)).

The MTSP7 protein antisense nucleic acid is generally an oligonucleotide, typically single-stranded DNA. In an embodiment, the oligonucleotide includes a sequence antisense to a portion of human MTSP7 protein. The oligonucleotide can be modified at any position on its structure with substituents generally known in the art.

The MTSP7 protein antisense oligonucleotide can include at least one modified base moiety which is selected from the group including, but not limited to 5-fluorouracil, 5-bromouracil, 5-chlorouracil, 5-iodouracil, hypoxanthine, xanthine, 4-acetylcytosine, 5-(carboxyhydroxylmethyl) uracil, 5-carboxymethylaminomethyl-2-thiouridine, 5-carboxymethyl-aminomethyluracil, dihydrouracil, beta-D-galactosylqueosine, inosine,

N6-isopentenyladenine, 1-methylguanine, 1-methylinosine, 2,2-dimethylguanine, 2-methyladenine, 2-methylguanine, 3-methylcytosine, 5-methylcytosine, N6-adenine, 7-methylguanine, 5-methylaminomethyluracil, 5-methoxyaminomethyl-2-thiouracil, beta-D-mannosylqueosine, 5'-methoxycarboxymethyluracil, 5-methoxyuracil, 2-methylthio-N6-isopentenyladenine, uracil-5-oxyacetic acid (v), wybutoxosine, pseudouracil, queosine, 2-thiocytosine, 5-methyl-2-thiouracil, 2-thiouracil, 4-thiouracil, 5-methyluracil, uracil-5-oxyacetic acid methylester, uracil-5-oxyacetic acid (v), 5-methyl-2-thiouracil, 3-(3-amino-3-N-2-carboxypropyl) uracil, (acp3)w, and 2,6-diaminopurine.

In another embodiment, the oligonucleotide includes at least one modified sugar moiety selected from the group including but not limited to arabinose, 2-fluoroarabinose, xylulose, and hexose. The oligonucleotide can include at least one modified phosphate backbone selected from a phosphorothioate, a phosphorodithioate, a phosphoramidothioate, a phosphoramidate, a phosphordiamidate, a methylphosphonate, an alkyl phosphotriester, and a formacetal or analog thereof.

The oligonucleotide can be an α-anomeric oligonucleotide. An α-anomeric oligonucleotide forms specific double-stranded hybrids with complementary RNA in which the strands run parallel to each other (Gautier et al., *Nucl. Acids Res.* 15:6625-6641 (1987)).

The oligonucleotide can be conjugated to another molecule, *e.g.*, a peptide, hybridization triggered cross-linking agent, transport agent and hybridization-triggered cleavage agent.

The oligonucleotides can be synthesized by standard methods known in the art, *e.g.* by use of an automated DNA synthesizer (such as are commercially available from Biosearch, Applied Biosystems). As examples, phosphorothioate oligonucleotides can be synthesized by the method of Stein et al. (*Nucl. Acids Res.* 16:3209 (1988)), methylphosphonate oligonucleotides can be prepared by use of controlled

pore glass polymer supports (Sarin et al., *Proc. Natl. Acad. Sci. U.S.A.* 85:7448-7451 (1988)).

In a specific embodiment, the MTSP7 protein antisense oligonucleotide includes catalytic RNA, or a ribozyme (see, *e.g.*, PCT International Publication WO 90/11364, published October 4, 1990; Sarver et al., *Science* 247:1222-1225 (1990)). In another embodiment, the oligonucleotide is a 2'-0-methylribonucleotide (Inoue et al., *Nucl. Acids Res.* 15:6131-6148 (1987)), or a chimeric RNA-DNA analogue (Inoue et al., *FEBS Lett.* 215:327-330 (1987)).

In an alternative embodiment, the MTSP7 protein antisense nucleic acid is produced intracellularly by transcription from an exogenous sequence. For example, a vector can be introduced *in vivo* such that it is taken up by a cell, within which cell the vector or a portion thereof is transcribed, producing an antisense nucleic acid (RNA). Such a vector would contain a sequence encoding the MTSP7 protein antisense nucleic acid. Such a vector can remain episomal or become chromosomally integrated, as long as it can be transcribed to produce the desired antisense RNA. Such vectors can be constructed by recombinant DNA technology methods standard in the art. Vectors can be plasmid, viral, or others known in the art, used for replication and expression in mammalian cells. Expression of the sequence encoding the MTSP7 protein antisense RNA can be by any promoter known in the art to act in mammalian, including human, cells. Such promoters can be inducible or constitutive. Such promoters include but are not limited to: the SV40 early promoter region (Bernoist and Chambon, *Nature* 290:304-310 (1981), the promoter contained in the 3' long terminal repeat of Rous sarcoma virus (Yamamoto et al., *Cell* 22:787-797 (1980), the herpes thymidine kinase promoter (Wagner et al., *Proc. Natl. Acad. Sci. U.S.A.* 78:1441-1445 (1981), the regulatory sequences of the metallothionein gene (Brinster et al., *Nature* 296:39-42 (1982)).

The antisense nucleic acids include sequence complementary to at least a portion of an RNA transcript of an MTSP7 protein gene, including a human MTSP7 protein gene. Absolute complementarily, although desirable, is not required.

The amount of MTSP7 protein antisense nucleic acid that will be effective in the treatment or prevention of neoplastic disease will depend on the nature of the disease, and can be determined empirically by standard clinical techniques. Where possible, it is desirable to determine the antisense cytotoxicity in cells *in vitro*, and then in useful animal model systems prior to testing and use in humans.

2. RNA interference

For example, RNA interference (RNAi) (see, *e.g.* Chuang *et al.* (2000) *Proc. Natl. Acad. Sci. U.S.A. 97*:4985) can be employed to inhibit the expression of a gene encoding an MTSP7. Interfering RNA (RNAi) fragments, particularly double-stranded (ds) RNAi, can be used to generate loss-of- MTSP7 function. Methods relating to the use of RNAi to silence genes in organisms including, mammals, C. elegans, Drosophila and plants, and humans are known (see, *e.g.*, Fire *et al.* (1998) *Nature 391*:806-811 Fire (1999) *Trends Genet. 15*:358-363; Sharp (2001) *Genes Dev. 15*:485-490; Hammond, *et al.* (2001) *Nature Rev. Genet.2*:110-1119; Tuschl (2001) *Chem. Biochem. 2*:239-245; Hamilton *et al.* (1999) *Science 286*:950-952; Hammond *et al.* (2000) *Nature 404*:293-296; Zamore *et al.* (2000) *Cell 101*:25-33; Bernstein *et al.* (2001) *Nature 409*: 363-366; Elbashir *et al.* (2001) *Genes Dev. 15*:188-200; Elbashir *et al.* (2001) *Nature 411*:494-498; International PCT application No. WO 01/29058; International PCT application No. WO 99/32619). Double-stranded RNA (dsRNA)-expressing constructs are introduced into a host, such as an animal or plant using, a replicable vector that remains episomal or integrates into the genome. By selecting appropriate sequences, expression of dsRNA can interfere with accumulation of endogenous mRNA encoding an MTSP7. RNAi can also

be used to inhibit expression *in vitro*. Regions include at least about 21 (or 21) nucleotides that are selective (i.e. unique) for MTSP7 are used to prepare the RNAi. Smaller fragments of about 21 nucleotides can be transformed directly into cells; larger RNAi dsRNA molecules are generally introduced using vectors that encode them. dsRNA molecules are at least about 21 bp long or longer, such as 50, 100, 150, 200 and longer.

3. Gene Therapy

In an exemplary embodiment, nucleic acids that include a sequence of nucleotides encoding an MTSP7 protein or functional domains or derivative thereof, are administered to promote MTSP7 protein function, by way of gene therapy. Gene therapy refers to therapy performed by the administration of a nucleic acid to a subject. In this embodiment, the nucleic acid produces its encoded protein that mediates a therapeutic effect by promoting MTSP7 protein function. Any of the methods for gene therapy available in the art can be used (see, Goldspiel et al., *Clinical Pharmacy* 12:488-505 (1993); Wu and Wu, *Biotherapy* 3:87-95 (1991); Tolstoshev, *An. Rev. Pharmacol. Toxicol.* 32:573-596 (1993); Mulligan, *Science* 260:926-932 (1993); and Morgan and Anderson, *An. Rev. Biochem.* 62:191-217 (1993); *TIBTECH* 11(5):155-215 (1993). For example, one therapeutic composition for gene therapy includes an MTSP7 protein-encoding nucleic acid that is part of an expression vector that expresses an MTSP7 protein or domain, fragment or chimeric protein thereof in a suitable host. In particular, such a nucleic acid has a promoter operably linked to the MTSP7 protein coding region, the promoter being inducible or constitutive, and, optionally, tissue-specific. In another particular embodiment, a nucleic acid molecule is used in which the MTSP7 protein coding sequences and any other desired sequences are flanked by regions that promote homologous recombination at a desired site in the genome, thus providing for intrachromosomal expression of the MTSP protein nucleic acid (Koller and

Smithies, *Proc. Natl. Acad. Sci. USA* 86:8932-8935 (1989); Zijlstra et al., *Nature* 342:435-438 (1989)).

Delivery of the nucleic acid into a patient can be either direct, in which case the patient is directly exposed to the nucleic acid or nucleic acid-carrying vector, or indirect, in which case, cells are first transformed with the nucleic acid *in vitro*, then transplanted into the patient. These two approaches are known, respectively, as *in vivo* or *ex vivo* gene therapy.

In a specific embodiment, the nucleic acid is directly administered *in vivo*, where it is expressed to produce the encoded product. This can be accomplished by any of numerous methods known in the art, *e.g.*, by constructing it as part of an appropriate nucleic acid expression vector and administering it so that it becomes intracellular, *e.g.*, by infection using a defective or attenuated retroviral or other viral vector (see U.S. Patent No. 4,980,286), or by direct injection of naked DNA, or by use of microparticle bombardment (*e.g.*, a gene gun; Biolistic, Dupont), or coating with lipids or cell-surface receptors or transfecting agents, encapsulation in liposomes, microparticles, or microcapsules, or by administering it in linkage to a peptide which is known to enter the nucleus, by administering it in linkage to a ligand subject to receptor-mediated endocytosis (see e.g., Wu and Wu, *J. Biol. Chem.* 262:4429-4432 (1987)) (which can be used to target cell types specifically expressing the receptors). In another embodiment, a nucleic acid-ligand complex can be formed in which the ligand is a fusogenic viral peptide to disrupt endosomes, allowing the nucleic acid to avoid lysosomal degradation. In yet another embodiment, the nucleic acid can be targeted *in vivo* for cell specific uptake and expression, by targeting a specific receptor (see, e.g., PCT Publications WO 92/06180 dated April 16, 1992 (Wu et al.); WO 92/22635 dated December 23, 1992 (Wilson et al.); WO92/20316 dated November 26, 1992 (Findeis et al.); WO93/14188 dated July 22, 1993 (Clarke et al.), WO 93/20221 dated October 14,

1993 (Young)). Alternatively, the nucleic acid can be introduced intracellularly and incorporated within host cell DNA for expression, by homologous recombination (Koller and Smithies, *Proc. Natl. Acad. Sci. USA* 86:8932-8935 (1989); Zijlstra et al., *Nature* 342:435-438 (1989)).

In a specific embodiment, a viral vector that contains the MTSP7 protein nucleic acid is used. For example, a retroviral vector can be used (see Miller et al., *Meth. Enzymol.* 217:581-599 (1993)). These retroviral vectors have been modified to delete retroviral sequences that are not necessary for packaging of the viral genome and integration into host cell DNA. The MTSP7 protein nucleic acid to be used in gene therapy is cloned into the vector, which facilitates delivery of the gene into a patient. More detail about retroviral vectors can be found in Boesen et al., *Biotherapy* 6:291-302 (1994), which describes the use of a retroviral vector to deliver the mdr1 gene to hematopoietic stem cells in order to make the stem cells more resistant to chemotherapy. Other references illustrating the use of retroviral vectors in gene therapy are: Clowes et al., *J. Clin. Invest.* 93:644-651 (1994); Kiem et al., *Blood* 83:1467-1473 (1994); Salmons and Gunzberg, *Human Gene Therapy* 4:129-141 (1993); and Grossman and Wilson, *Curr. Opin. in Genetics and Devel.* 3:110-114 (1993).

Adenoviruses are other viral vectors that can be used in gene therapy. Adenoviruses are especially attractive vehicles for delivering genes to respiratory epithelia. Adenoviruses naturally infect respiratory epithelia where they cause a mild disease. Other targets for adenovirus-based delivery systems are liver, the central nervous system, endothelial cells, and muscle. Adenoviruses have the advantage of being capable of infecting non-dividing cells. Kozarsky and Wilson, *Current Opinion in Genetics and Development* 3:499-503 (1993) present a review of adenovirus-based gene therapy. Bout et al., *Human Gene Therapy* 5:3-10 (1994) demonstrated the use of adenovirus vectors to transfer genes to the respiratory epithelia of rhesus monkeys. Other instances of the use of

adenoviruses in gene therapy can be found in Rosenfeld et al., *Science* 252:431-434 (1991); Rosenfeld et al., *Cell* 68:143-155 (1992); and Mastrangeli et al., *J. Clin. Invest.* 91:225-234 (1993). Adeno-associated virus (AAV) has been used in gene therapy (Walsh et al., *Proc. Soc. Exp. Biol. Med.* 204:289-300 (1993).

Another approach to gene therapy involves transferring a gene to cells in tissue culture by such methods as electroporation, lipofection, calcium phosphate mediated transfection, or viral infection. Usually, the method of transfer includes the transfer of a selectable marker to the cells. The cells are then placed under selection to isolate those cells that have taken up and are expressing the transferred gene. Those cells are then delivered to a patient.

In this embodiment, the nucleic acid is introduced into a cell prior to administration *in vivo* of the resulting recombinant cell. Such introduction can be carried out by any method known in the art, including but not limited to transfection, electroporation, microinjection, infection with a viral or bacteriophage vector containing the nucleic acid sequences, cell fusion, chromosome-mediated gene transfer, microcell-mediated gene transfer and spheroplast fusion. Numerous techniques are known in the art for the introduction of foreign genes into cells (see *e.g.*, Loeffler and Behr, *Meth. Enzymol.* 217:599-618 (1993); Cohen et al., *Meth. Enzymol.* 217:618-644 (1993); Cline, *Pharmac. Ther.* 29:69-92 (1985)) and can be used, provided that the necessary developmental and physiological functions of the recipient cells are not disrupted. The technique should provide for the stable transfer of the nucleic acid to the cell, so that the nucleic acid is expressible by the cell and also can be heritable and expressible by its cell progeny.

The resulting recombinant cells can be delivered to a patient by various methods known in the art. In certain embodiments, epithelial cells are injected, *e.g.*, subcutaneously. In another embodiment, recombinant skin cells can be applied as a skin graft onto the patient.

Recombinant blood cells (*e.g.*, hematopoietic stem or progenitor cells) are generally administered intravenously. The amount of cells envisioned for use depends on the desired effect, patient state and other parameter, and can be determined by one skilled in the art.

Cells into which a nucleic acid can be introduced for purposes of gene therapy encompass any desired, available cell type, and include but are not limited to epithelial cells, endothelial cells, keratinocytes, fibroblasts, muscle cells, hepatocytes; blood cells such as T lymphocytes, B lymphocytes, monocytes, macrophages, neutrophils, eosinophils, megakaryocytes, granulocytes; various stem or progenitor cells, in particular hematopoietic stem or progenitor cells, *e.g.*, as obtained from bone marrow, hepatocytes, umbilical cord blood, peripheral blood and fetal liver and other sources of such cells.

In certain embodiments, the cell used for gene therapy is autologous to the patient. In an embodiment in which recombinant cells are used in gene therapy, an MTSP7 protein nucleic acid is introduced into the cells such that it is expressible by the cells or their progeny, and the recombinant cells are then administered *in vivo* for therapeutic effect. In a specific embodiment, stem or progenitor cells are used. Any stem and/or progenitor cells which can be isolated and maintained *in vitro* can potentially be used in accordance with this embodiment. Such stem cells include but are not limited to hematopoietic stem cells (HSC), stem cells of epithelial tissues such as the skin and the lining of the gut, embryonic heart muscle cells, liver stem cells (PCT Publication WO 94/08598, dated April 28, 1994), and neural stem cells (Stemple and Anderson, *Cell* 71:973-985 (1992)).

Epithelial stem cells (ESCs) or keratinocytes can be obtained from tissues such as the skin and the lining of the gut by known procedures (Rheinwald, *Meth. Cell Bio.* 21A:229 (1980)). In stratified epithelial tissue such as the skin, renewal occurs by mitosis of stem cells within the germinal layer, the layer closest to the basal lamina. Stem cells within

the lining of the gut provide for a rapid renewal rate of this tissue. ESCs or keratinocytes obtained from the skin or lining of the gut of a patient or donor can be grown in tissue culture (Rheinwald, *Meth. Cell Bio.* 21A:229 (1980); Pittelkow and Scott, *Cano Clinic Proc.* 61:771 (1986)). If the ESCs are provided by a donor, a method for suppression of host versus graft reactivity (*e.g.*, irradiation, drug or antibody administration to promote moderate immunosuppression) can also be used.

With respect to hematopoietic stem cells (HSC), any technique which provides for the isolation, propagation, and maintenance *in vitro* of HSC can be used in this embodiment. Techniques by which this can be accomplished include (a) the isolation and establishment of HSC cultures from bone marrow cells isolated from the future host, or a donor, or (b) the use of previously established long-term HSC cultures, which can be allogeneic or xenogeneic. Non-autologous HSC are used generally in conjunction with a method of suppressing transplantation immune reactions of the future host/patient. In a particular embodiment, human bone marrow cells can be obtained from the posterior iliac crest by needle aspiration (see, *e.g.*, Kodo et al., *J. Clin. Invest.* 73:1377-1384 (1984)). In certain embodiments, the HSCs can be made highly enriched or in substantially pure form. This enrichment can be accomplished before, during, or after long-term culturing, and can be done by any techniques known in the art. Long-term cultures of bone marrow cells can be established and maintained by using, for example, modified Dexter cell culture techniques (Dexter et al., *J. Cell Physiol.* 91:335 (1977) or Witlock-Witte culture techniques (Witlock and Witte, *Proc. Natl. Acad. Sci. USA* 79:3608-3612 (1982)).

In a specific embodiment, the nucleic acid to be introduced for purposes of gene therapy includes an inducible promoter operably linked to the coding region, such that expression of the nucleic acid is controllable by controlling the presence or absence of the appropriate inducer of transcription.

3. Prodrugs

A method for treating tumors is provided. The method is practiced by administering a prodrug that is specifically cleaved by an MTSP7 to release an active drug. Upon contact with a cell that expresses MTSP7 activity, the prodrug is converted into an active drug. The prodrug can be a conjugate that contains the active agent, such as an anti-tumor drug, such as a cytotoxic agent, or other therapeutic agent, linked, linked to a substrate for the targeted MTSP7, such that the drug or agent is inactive or unable to enter a cell, in the conjugate, but is activated upon cleavage. The prodrug, for example, can contain an oligopeptide, typically a relatively short, less than about 10 amino acids peptide, that is selectively proteolytically cleaved by the targeted MTSP7. Cytotoxic agents, include, but are not limited to, alkylating agents, antiproliferative agents and tubulin binding agents. Others include, vinca drugs, mitomycins, bleomycins and taxanes.

M. ANIMAL MODELS

Transgenic animal models are provided herein. Such an animal can by produced by promoting recombination between an exogenous MTSP7 gene that could be over-expressed or mis-expressed, such as by expression under a strong promoter, via homologous or other recombination event. For example, transgenic animals can be produced by introducing the nucleic acid using vectors or other modes of gene delivery into a germline cell, such as an embryonic stem cell. Typically the nucleic acid is introduced, such as an embryonic stem cell, which is then injected by transforming embryo-derived stem (ES) cells with a vector containing the MTSP7 protein-encoding nucleic acid followed by injecting the ES cells into a blastocyst, and implanting the blastocyst into a foster mother, followed by the birth of a transgenic animal. Generally introduction into a chromosome of the animal occurs by a recombination between the heterologous MTSP7-encoding nucleic acid and endogenous

nucleic acid. The heterologous nucleic acid can be targeted to a specific chromosome.

In some instances, knockout animals can be produced. Such an animal can be initially produced by promoting homologous recombination between an MTSP7 protein gene in its chromosome and an exogenous MTSP7 protein gene that has been rendered biologically inactive (typically by insertion of a heterologous sequence, *e.g.*, an antibiotic resistance gene). In one embodiment, this homologous recombination is performed by transforming embryo-derived stem (ES) cells with a vector containing the insertionally inactivated MTSP7 protein gene, such that homologous recombination occurs, followed by injecting the ES cells into a blastocyst, and implanting the blastocyst into a foster mother, followed by the birth of the chimeric animal ("knockout animal") in which an MTSP7 protein gene has been inactivated (see Capecchi, *Science* 244:1288-1292 (1989)). The chimeric animal can be bred to produce additional knockout animals. Such animals include, but are not limited to, mice, hamsters, sheep, pigs, cattle, and other non-human mammals. For example, a knockout mouse is produced. Such knockout animals are expected to develop or be predisposed to developing neoplastic diseases and thus can have use as animal models of such diseases *e.g.*, to screen for or test molecules for the ability to treat or prevent such diseases or disorders. Such an animal can be initially produced by promoting homologous recombination between an MTSP7 gene in its chromosome and an exogenous MTSP7 protein gene that would be over-expressed or mis-expressed (generally by expression under a strong promoter). In an embodiment, this homologous recombination is carried out by transforming embryo-derived stem (ES) cells with a vector containing the over-expressed or mis-expressed MTSP7 protein gene, such that homologous recombination occurs, followed by injecting the ES cells into a blastocyst, and implanting the blastocyst into a foster mother, followed by the birth of the chimeric animal in which an MTSP7 gene has been

over-expressed or mis-expressed (see Capecchi, *Science* 244:1288-1292 (1989)). The chimeric animal can be bred to produce additional animals with over-expressed or mis-expressed MTSP7 protein. Such animals include, but are not limited to, mice, hamsters, sheep, pigs, cattle and other non-human mammals. In a specific embodiment, a mouse with over-expressed or mis-expressed MTSP7 protein is produced.

The following examples are included for illustrative purposes only and are not intended to limit the scope of the invention.

EXAMPLE 1

Identification of MTSP7

The protein sequence of the protease domain of matriptase (MTSP1; accession number AF118224) was used to search the human HTGS (high throughput genomic sequence) database using the tblastn algorithm. This search and alignment algorithm compares a protein query sequence against a nucleotide sequence database dynamically translated in all six reading frames (both strands). Several potential new serine proteases were identified, among them was one designated herein as MTSP7. The translated sequence of MTSP7 has 53% identity to matriptase and 48% identity with endotheliase 1 (accession number AF064819). A search of a human genome database revealed identity in clones designated AP002824 and AC012571; and searches of human EST databases revealed several matches as well.

Identification of tissue source for cloning of MTSP7

Using the nucleotide sequence of MTSP7 derived from the genomic sequence, two gene specific oligonucleotide primers were designed. The sequence for the 5' end primer is 5'-AATGGCCATGGCAGGCCAGCCTCC-3' SEQ ID No. 5 and that of the 3' end is 5'-GTCCCCAACTTACTATACCTACAATGTACCAG-3' SEQ ID No. 6. These primers were used to screen a panel of 8 cDNA libraries derived normal human tissues (Human Multiple Tissue cDNA Panel I;

Clontech, Palo Alto, CA; catalog no. K1420-1). A major band was detected in human placenta, and subsequent sequence analysis showed that the nucleotide sequence of this DNA fragment matched that of the genomic MTSP7 clone. The human placenta was then chosen as the tissue source for isolation of the full length cDNA.

5'- and 3'- rapid amplification of cDNA ends (RACE)

To obtain the full-length cDNA of MTSP7, 5'- and 3'-RACE reactions were performed. RACE-ready cDNA library from human placenta was prepared using the SMART RACE cDNA amplification kit (Clontech, Palo Alto, CA; catalog no. K1811-1). Two gene specific primers were used: 5'-GTCCCCAACTTACTATACCTACAATGTACCAG -3' SEQ ID No. 7 for 5'-RACE reaction and 5'-AATGGCCATGGCAGGCCAGCCTCC -3' SEQ ID No. 8 for 3'-RACE reaction. A ~1.5 kbp cDNA fragment was obtained from the 5'-RACE reaction. The 3'-RACE reaction also yielded a ~1.5 kbp fragment. The fragments were subcloned into pCR2.1-TOPO TA cloning vector (Invitrogen, Carlsbad, CA; catalog no. K-4500-01). The resulting clones were analyzed by Southern analysis using the cDNA insert originally derived from human placenta as a probe and by DNA sequence analysis.

Domain organization of MTSP7 and homology to endotheliase 1

Sequence analysis of the translated MTSP7 coding sequence indicated that MTSP7 is a type-II membrane-type serine protease. It has a transmembrane domain at the N-terminus, followed by a SEA (sea urchin sperm protein-enterokinase-agrin) domain. Studies suggest that the SEA domain can function in the binding of carbohydrate moieties. The C-terminus contains a trypsin-like serine protease domain characterized by the presence of a protease activation cleavage site at the beginning of the domain and the catalytic triad residues (histidine, aspartate and serine) in 3 highly-conserved regions of the catalytic domain. Alignment of the protein sequence with that of endotheliase 1 showed 42% identity with the full-length protein and 58% identity with the protease domain.

Amplification of cDNA encoding full-length protease domain of MTSP7

To obtain the cDNA fragment encoding the protease domain of MTSP7, an end-to-end PCR amplification using gene-specific primers and the SMART RACE cDNA library from human placenta was used. The two primers used were: 5'- TGCCATTACCAGCATCCTCTTCTACTCAAAG -3' for the 5' end SEQ ID No. 9 and 5'-CCATGTGTATAACTCACGGACAATCCACACTAC -3' SEQ ID No. 10 for the 3' end. The 5' primer contained the sequence that encodes a region immediately upstream of the start of the MTSP7 protease domain (MPLPASSSTQ; SEQ ID No. 11). The 3' primer corresponds to the sequence flanking the stop codon (underlined) and the sequence immediately downstream of the stop codon. A 760-bp fragment was amplified from the human placenta cDNA library. The PCR product was isolated and purified using the QIAquick gel extraction kit (Qiagen, Valencia, CA; catalog no. 28704). The MTSP7 PCR product was used to amplify the cDNA fragment containing the appropriate restriction sites for subcloning into the *Pichia* vector, pPIC9KX. The gene-specific primers used were:
5'- TCTCTCGAGAAAAGAATTGTCCAAGGAAGGGAAACAGCTATG-3' SEQ ID No. 12 at the 5' end and
5'-ATAGCGGCCGCACA**CTA**CATACCAGTCTTTGAGGCAATC-3' SEQ ID No. 13 at the 3' end. The 5' end primer contained an XhoI site (underlined) immediately upstream of the Pichia protease cleavage site and part of the MTSP7 protease domain (KRIVQGRETAM; SEQ ID No. 14), while the 3' end primer contained a NotI site (underlined) downstream of the stop codon (in bold).

Gene expression profile of MTSP7 in normal tissues and tumor cell lines

To obtain information regarding the gene expression profile of the MTSP7 transcript, the MTSP7 cDNA fragment obtained from human placenta was used to probe an RNA dot blot composed of 76 different human tissues (Human Multiple Tissue Expression (MTE) Array; Clontech,

Palo Alto, CA; catalog no. 7775-1). Results show that MTSP7 is ubiquitously expressed, with highest levels (in decreasing intensity signal) found in kidney, spleen, placenta, lung, liver, bone marrow, pituitary gland, spinal cord, peripheral blood leukocyte, lymph node, ovary, mammary gland, adrenal gland, thyroid gland, bladder, uterus and prostate. It is also highly expressed in lung carcinoma (A549 cell line), leukemia (K-562 cell line) and cervical carcinoma (HeLaS3 cell line).

Sequence analysis

MTSP7 DNA and protein sequences were analyzed using MacVector (version 6.5; Oxford Molecular Ltd., Madison, WI). The full length cDNA of MTSP7 is 2,100 bp long with an ORF composed of 1,317 bp which translate to a 438-amino acid protein (SEQ ID Nos. 15 and 16). The cDNA encoding the protease domain in MTSP7 is composed of 702 base pairs, which translate to a 233-amino acid protein sequence and stop codon. The following are ORF cDNA sequence and the translated protein sequence of MTSP7 (see SEQ ID No. 15 and 16).

MTSP7/full length cDNA sequence Range: 1 to 2100

ATGATGTACACACCTGTTGAATTTTCAGAAGCTGAAT
TCTCACGAGCTGAATATCAAAGAAAGCAGCAATTTTG
GGACTCAGTACGGCTAGCTCTTTTCACATTAGCAATT
GTAGCAATCATAGGAATTGCAATTGGTATTGTTACTC
ATTTTGTTGTTGAGGATGATAAGTCTTTCTATTACCT
TGCCTCTTTTAAAGTCACAAATATCAAATATAAAGAA
AATTATGGCATAAGATCTTCAAGAGAGTTTATAGAAA
GGAGTCATCAGATTGAAAGAATGATGTCTAGGATATT
TCGACATTCTTCTGTAGGCGGTCGATTTATCAAATCT
CATGTTATCAAATTAAGTCCAGATGAACAAGGTGTGG
ATATTCTTATAGTGCTCATATTTCGATACCCATCTAC
TGATAGTGCTGAACAAATCAAGAAAAAAATTGAAAAG
GCTTTATATCAAAGTTTGAAGACCAAACAATTGTCTT
TGACCATAAACAAACCATCATTTAGACTCACACCTAT
TGACAGCAAAAAGATGAGGAATCTTCTCAACAGTCGC
TGTGGAATAAGGATGACATCTTCAAACATGCCATTAC
CAGCATCCTCTTCTACTCAAAGAATTGTCCAAGGAAG
GGAAACAGCTATGGAAGGGGAATGGCCATGGCAGGCC
AGCCTCCAGCTCATAGGGTCAGGCCATCAGTGTGGAG
CCAGCCTCATCAGTAACACATGGCTGCTCACAGCAGC
TCACTGCTTTTGGAAAAATAAAGACCCAACTCAATGG
ATTGCTACTTTTGGTGCAACTATAACACCACCCGCAG
TGAAACGAAATGTGAGGAAAATTATTCTTCATGAGAA
TTACCATAGAGAAACAAATGAAAATGACATTGCTTTG
GTTCAGCTCTCTACTGGAGTTGAGTTTTCAAATATAG

TCCAGAGAGTTTGCCTCCCAGACTCATCTATAAAGTT
GCCACCTAAAACAAGTGTGTTCGTCACAGGATTTGGA
TCCATTGTAGATGATGGACCTATACAAAATACACTTC
GGCAAGCCAGAGTGGAAACCATAAGCACTGATGTGTG
TAACAGAAAGGATGTGTATGATGGCCTGATAACTCCA
GGAATGTTATGTGCTGGATTCATGGAAGGAAAAATAG
ATGCATGTAAGGGAGATTCTGGTGGACCTCTGGTTTA
TGATAATCATGACATCTGGTACATTGTAGGTATAGTA
AGTTGGGGACAATCATGTGCACTTCCCAAAAAACCTG
GAGTCTACACCAGAGTAACTAAGTATCGAGATTGGAT
TGCCTCAAAGACTGGTATGTAG

MTSP7-coding region-cDNA and protein sequences Range: 45 to 1361

MMYTPVEFSEAEFSRAEYQRKQQFWDSVRLALFTLAIVA
IIGIAIGIVTHFVVEDDKSFYYLASFKVTNIKYKENYGI
RSSREFIERSHQIERMMSRIFRHSSVGGRFIKSHVIKLS
PDEQGVDILIVLIFRYPSTDSAEQIKKKIEKALYQSLKT
KQLSLTINKPSFRLTPIDSKKMRNLLNSRCGIRMTSSNM
PLPASSSTQRIVQGRETAMEGEWPWQASLQLIGSGHQCG
ASLISNTWLLTAAHCFWKNKDPTQWIATFGATITPPAVK
RNVRKIILHENYHRETNENDIALVQLSTGVEFSNIVQRV
CLPDSSIKLPPKTSVFVTGFGSIVDDGPIQNTLRQARVE
TISTDVCNRKDVYDGLITPGMLCAGFMEGKIDACKGDSG
GPLVYDNHDIWYIVGIVSWGQSCALPKKPGVYTRVTKYR
DWIASKTGM

EXAMPLE 2

Cloning and expression of the protease domain of MTSP7 for expression

C122S mutagenesis of the Protease domain of MTSP7

The gene encoding the protease domain of MTSP7 (the N-terminus starting at the I206) was mutagenized by PCR SOE (PCR-based splicing by overlap extension) to replace the unpaired cysteine at position 122 (chymotrypsin numbering system; cysteine 313 in MTSP7 sequence) with a serine. Two overlapping gene fragments, each replacing the TGC codon for cysteine with an AGC codon for serine at position 122 were PCR amplified using the following primers: for the 5' gene fragment, TCTCTCGAGAAAAGAATTGTCCAAGGAAGGGAAACAGCTATG SEQ ID NO. 19) and AGATGAGTCTGGGAGGCTAACTCTCTGGACTAT (SEQ ID No. 20); for the 3' gene fragment, ATTCGCGGCCGCCTACATACCAGTCTTTGAGGCAAT (SEQ ID No. 21) and ATAGTCCAGAGAGTTAGCCTCCCAGACTCATCT (SEQ ID No. 22).

The amplified gene fragments were purified on a 1% agarose gel, mixed and reamplified by PCR to produce the full length coding sequence for the protease domain of MTSP7 C122S. This sequence was then cut with restriction enzymes NotI and XhoI, and ligated into the XhoI/NotI sites of Pichia vector pPic9KX.

Expression of MTSP-7 by fermentation of Pichia

Nucleic acid encoding each the MTSP7 protease domain thereof was cloned (with a C313S mutation) into a derivative, modified by removal of a restriction site as described below, of the *Pichia pastoris* vector pPIC9K (available from Invitrogen; see SEQ ID NO. 45). Plasmid pPIC9k features include the 5' AOX1 promoter fragment at 1-948; 5' AOX1 primer site at 855-875; alpha-factor secretion signal(s) at 949-1218; alpha-factor primer site at 1152-1172; multiple cloning site at 1192-1241; 3' AOX1 primer site at 1327-1347; 3' AOX1 transcription termination region at 1253-1586; HIS4 ORF at 4514-1980; kanamycin resistance gene at 5743-4928; 3' AOX1 fragment at 6122-6879; ColE1 origin at 7961-7288; and the ampicillin resistance gene at 8966-8106. The plasmid used herein is derived from pPIC9K by eliminating the XhoI site in the kanamycin resistance gene and the resulting vector is herein designated pPIC9KX.

Fermentation

P. pastoris clone GS115/pPIC9K:MTSP7 C122S Sac SC2 that expresses the C122S mutant form of MTSP7 was fermented at the 5 liter scale. An overnight culture of 200 ml (OD600 of approximately 12) was used to inoculate 3.2 liters of fermentation medium in each of two Bioflo vessels (New Brunswick Scientific, Edison, NJ). The batch phase complex medium contained 10 g/l yeast extract, 20 g/l peptone, 40 g/l glycerol, 5 g/l ammonium sulfate, 0.2 g/l calcium sulfate(dihydrate), 2 g/l magnesium sulfate(heptahydrate), 2 g/l potassium sulfate, 25 g/l sodium hexametaphosphate, and 4.35 ml/l PTM1. The culture was grown at a pH of 6.0 and a temperature of 28 °C. Concentrated ammonium

hydroxide was used to maintain the pH of the culture. KFO 880 (KABO Chemicals, Cheyenne,WY) was used as needed to control foaming.

The batch phase of the fermentation lasted about 26 hours at which time the culture had consumed all of the initial glycerol in the media. A substrate limited fed-batch of 50% (w/v) glycerol was initiated at 18 ml/l x hr at this point and continued for about 4 hours. The culture reached a density of about 200 g/l wet cell weight by this point.

Methanol induction was initiated following the end of the glycerol fed-batch phase. The culture was transitioned to methanol utilization (see, Zhang *et al.* (2000) Modeling *Pichia pastoris* Growth on Methanol and Optimizing the Production of a Recombinant Protein, the Heavy-Chain Fragment C of Botulinum Neurotoxin, Serotype A. Biotechnology and Bioengineering Vol. 70, No 1 October 5, 2000) by adding 1.5 ml of methanol per liter of culture and linearly decreasing the glycerol feed rate from 18 ml/l x hr to 0 ml/l x hr over a 3 hour period. The methanol addition served as an on-line calibration of the MeOH Sensor (Raven Biotech, Vancouver, BC, Canada) that was used to control the fermenter throughout induction. After the initial amount of methanol was utilized, as indicated by the MeOH Sensor, another 1.5 ml/l was added to the culture and the MeOH sensor was used to control the methanol concentration in the fermenter at that level (i.e., 0.15%) throughout the induction phase. The methanol fed to the fermenter was supplemented with 2 ml/l PTM4 solution. The induction phase lasted about 42 hours.

Initial Work-up of MTSP-7 containing conditioned media:

The supernatant from each of the fermentations was harvested by centrifugation, pooled, and then was concentrated to about 0.5 liter using a 10 kDa ultrafiltration cartridge (A/G Technologies Corp., Needham, MA) on a SRT5 ultrafiltration system (North Carolina SRT, Cary, NC). The concentrate was drained from the system, and the system was rinsed with a volume of buffer (50 mM Tris, pH = 8.0, 50 mM NaCl, 0.005% Tween 80) equal to the initial volume of the concentrated material. The

concentrate and the rinse material were combined to yield the final ultrafiltration product of about 1 liter. A final clarification of the supernatant was done with a SartoBran 300 0.45 + 0.2 μm capsule filter (Sartorius Separations Div., Edgewood, NJ).

Purification of MTSP7:

After a 5L fermentation, cells were separated from the medium by centrifugation. The supernatant was brought to 40% saturation with ammonium sulfate and centrifuged. The pellet was dissolved in 250 mL 20 mM Hepes, 150 mM NaCl pH 7.5 (HS buffer). The resulting protein solution was stored at –20i° C n 50 mL aliquots. After thawing, 50 mL of protein solution was dialyzed against 4 L of HS buffer. To the dialysate, 4 mL of 10 % polyethylenimine was added, and the precipitate was removed by centrifugation at 20,000 rpm. The supernatant was diluted with HS buffer to a volume of 90 mL and 20 g of ammonium sulfate was added slowly. The resulting solution was applied onto an octyl sepharose column (2.5 cm x 10 cm) (Pharmacia) equilibrated with HS buffer containing 1.74 M ammonium sulfate at room temperature. After washing the column,with HS buffer containing 1.74 M ammonium sulfate, MTSP7 was eluted in a gradient (1.74 M – 0 ammonium sulfate in HS buffer). Active fractions were pooled (60 mL) and dialyzed against HS buffer overnight with one buffer change. The dialysate was batch-absorbed onto 20 mL benzamidine sepharose (Pharmacia) and washed with 4 column volumes HS buffer. MTSP 7 was eluted by HS/4 mM benzamidine. The protein appeared homogeneous by SDS-PAGE, and the identity of the protein was confirmed by amino acid sequencing.

EXAMPLE 3

Assays for identification of candidate compounds that modulate that activity of an MTSP

Assay for identifying inhibitors

The ability of test compounds to act as inhibitors of catalytic activity of an MTSP7 can be assessed in an amidolytic assay. The inhibitor-induced inhibition of amidolytic activity by a recombinant MTSP

or the protease domain portions thereof, can be measured by IC50 values in such an assay.

The protease domain of MTSP7 expressed in *Pichia pastoris* has been assayed in Costar 96 well tissue culture plates (Corning NY) for inhibition by various test compounds as follows . Approximately 1-10 nM protease is added without inhibitor, or with 100000 nM inhibitor and seven 1:6 dilutions into 1X direct buffer (29.2 mM Tris, pH 8.4, 29.2 mM Imidazole, 217 mM NaCl (100 μL final volume)), and allowed to incubate at room temperature for 30 minutes. 400 μM substrate S 2366 (DiaPharma, Westchester, OH) is added and the reaction is monitored in a SpectraMAX Plus microplate reader (Molecular Devices, Sunnyvale CA) by following change in absorbance at 405 nm for 20 minutes at 37°C.

EXAMPLE 4

Other Assays

These assays are described with reference to MTSP1, but such assays can be readily adapted for use with MTSP7.

Amidolytic Assay for Determining Inhibition of Serine Protease Activity of Matriptase or MTSP1

The ability of test compounds to act as inhibitors of rMAP catalytic activity was assessed by determining the inhibitor-induced inhibition of amidolytic activity by the MAP, as measured by IC_{50} values. The assay buffer was HBSA (10 mM Hepes, 150 mM sodium chloride, pH 7.4, 0.1% bovine serum albumin). All reagents were from Sigma Chemical Co. (St. Louis, MO), unless otherwise indicated.

Two IC_{50} assays (a) one at either 30-minutes or 60-minutes (a 30-minute or a 60-minute preincubation of test compound and enzyme) and (b) one at 0-minutes (no preincubation of test compound and enzyme) were conducted. For the IC_{50} assay at either 30-minutes or 60-minutes, the following reagents were combined in appropriate wells of a Corning microtiter plate: 50 microliters of HBSA, 50 microliters of the test compound, diluted (covering a broad concentration range) in HBSA (or

HBSA alone for uninhibited velocity measurement), and 50 microliters of the rMAP (Corvas International) diluted in buffer, yielding a final enzyme concentration of 250 pM as determined by active site filtration. Following either a 30-minute or a 60-minute incubation at ambient temperature, the assay was initiated by the addition of 50 microliters of the substrate S-2765 (N-α-Benzyloxycarbonyl-D-arginyl-L-glycyl-L-arginine-p-nitroaniline dihydrochloride; DiaPharma Group, Inc.; Franklin, OH) to each well, yielding a final assay volume of 200 microliters and a final substrate concentration of 100 μM (about 4-times K_m). Before addition to the assay mixture, S-2765 was reconstituted in deionized water and diluted in HBSA. For the IC_{50} assay at 0 minutes; the same reagents were combined: 50 microliters of HBSA, 50 microliters of the test compound, diluted (covering the identical concentration range) in HBSA (or HBSA alone for uninhibited velocity measurement), and 50 microliters of the substrate S-2765. The assay was initiated by the addition of 50 microliters of rMAP. The final concentrations of all components were identical in both IC_{50} assays (at 30- or 60- and 0-minute).

The initial velocity of chromogenic substrate hydrolysis was measured in both assays by the change of absorbance at 405 nM using a Thermo Max® Kinetic Microplate Reader (Molecular Devices) over a 5 minute period, in which less than 5% of the added substrate was used. The concentration of added inhibitor, which caused a 50% decrease in the initial rate of hydrolysis was defined as the respective IC_{50} value in each of the two assays (30- or 60-minutes and 0-minute).

***In vitro* enzyme assays for specificity determination**

The ability of compounds to act as a selective inhibitor of matriptase activity was assessed by determining the concentration of test compound that inhibits the activity of matriptase by 50%, (IC_{50}) as described in the above Example, and comparing IC_{50} value for matriptase to that determined for all or some of the following serine proteases:

thrombin, recombinant tissue plasminogen activator (rt-PA), plasmin, activated protein C, chymotrypsin, factor Xa and trypsin.

The buffer used for all assays was HBSA (10 mM HEPES, pH 7.5, 150 mM sodium chloride, 0.1% bovine serum albumin). The assay for IC_{50} determinations was conducted by combining in appropriate wells of a Corning microtiter plate, 50 microliters of HBSA, 50 microliters of the test compound at a specified concentration (covering a broad concentration range) diluted in HBSA (or HBSA alone for V_0 (uninhibited velocity) measurement), and 50 microliters of the enzyme diluted in HBSA. Following a 30 minute incubation at ambient temperature, 50 microliters of the substrate at the concentrations specified below were added to the wells, yielding a final total volume of 200 microliters. The initial velocity of chromogenic substrate hydrolysis was measured by the change in absorbance at 405 nm using a Thermo Max® Kinetic Microplate Reader over a 5 minute period in which less than 5% of the added substrate was used. The concentration of added inhibitor which caused a 50% decrease in the initial rate of hydrolysis was defined as the IC_{50} value.

Thrombin (fIIa) Assay

Enzyme activity was determined using the chromogenic substrate, Pefachrome t-PA (CH_3SO_2-D-hexahydrotyrosine-glycyl-L-Arginine-p-nitroaniline, obtained from Pentapharm Ltd.). The substrate was reconstituted in deionized water prior to use. Purified human α-thrombin was obtained from Enzyme Research Laboratories, Inc. The buffer used for all assays was HBSA (10 mM HEPES, pH 7.5, 150 mM sodium chloride, 0.1% bovine serum albumin).

IC_{50} determinations were conducted where HBSA (50 μL), α-thrombin (50 μl) (the final enzyme concentration is 0.5 nM) and inhibitor (50 μl) (covering a broad concentration range), were combined in appropriate wells and incubated for 30 minutes at room temperature prior to the addition of substrate Pefachrome-t-PA (50 μl) (the final substrate concentration is 250 μM, about 5 times Km). The initial velocity of

Pefachrome t-PA hydrolysis was measured by the change in absorbance at 405 nm using a Thermo Max® Kinetic Microplate Reader over a 5 minute period in which less than 5% of the added substrate was used. The concentration of added inhibitor which caused a 50% decrease in the initial rate of hydrolysis was defined as the IC_{50} value.

Factor Xa

Factor Xa catalytic activity was determined using the chromogenic substrate S-2765 (N-benzyloxycarbonyl-D-arginine-L-glycine-L-arginine-p-nitroaniline), obtained from DiaPharma Group (Franklin, OH). All substrates were reconstituted in deionized water prior to use. The final concentration of S-2765 was 250 μM (about 5-times Km). Purified human Factor X was obtained from Enzyme Research Laboratories, Inc. (South Bend, IN) and Factor Xa (FXa) was activated and prepared from it as described [Bock, P.E., Craig, P.A., Olson, S.T., and Singh, P. *Arch. Biochem. Biophys.* 273:375-388 (1989)]. The enzyme was diluted into HBSA prior to assay in which the final concentration was 0.25 nM.

Recombinant tissue plasminogen activator (rt-PA) Assay

rt-PA catalytic activity was determined using the substrate, Pefachrome t-PA (CH_3SO_2-D-hexahydrotyrosine-glycyl-L-arginine-p-nitro-aniline, obtained from Pentapharm Ltd.). The substrate was made up in deionized water followed by dilution in HBSA prior to the assay in which the final concentration was 500 micromolar (about 3-times Km). Human rt-PA (Activase®) was obtained from Genentech Inc. The enzyme was reconstituted in deionized water and diluted into HBSA prior to the assay in which the final concentration was 1.0 nM.

Plasmin Assay

Plasmin catalytic activity was determined using the chromogenic substrate, S-2366 [L-pyroglutamyl-L-prolyl-L-arginine-p-nitroaniline hydrochloride], which was obtained from DiaPharma group. The substrate was made up in deionized water followed by dilution in HBSA prior to the assay in which the final concentration was 300 micromolar

(about 2.5-times Km). Purified human plasmin was obtained from Enzyme Research Laboratories, Inc. The enzyme was diluted into HBSA prior to assay in which the final concentration was 1.0 nM.

Activated Protein C (aPC) Assay

aPC catalytic activity was determined using the chromogenic substrate, Pefachrome PC (delta-carbobenzloxy-D-lysine-L-prolyl-L-arginine-p-nitroaniline dihydrochloride), obtained from Pentapharm Ltd.). The substrate was made up in deionized water followed by dilution in HBSA prior to the assay in which the final concentration was 400 micromolar (about 3-times Km). Purified human aPC was obtained from Hematologic Technologies, Inc. The enzyme was diluted into HBSA prior to assay in which the final concentration was 1.0 nM.

Chymotrypsin Assay

Chymotrypsin catalytic activity was determined using the chromogenic substrate, S-2586 (methoxy-succinyl-L-arginine-L-prolyl-L-tyrosyl-p-nitroanilide), which was obtained from DiaPharma Group. The substrate was made up in deionized water followed by dilution in HBSA prior to the assay in which the final concentration was 100 micromolar (about 9-times Km). Purified (3X-crystallized; CDI) bovine pancreatic alpha-chymotrypsin was obtained from Worthington Biochemical Corp. The enzyme was reconstituted in deionized water and diluted into HBSA prior to assay in which the final concentration was 0.5 nM.

Trypsin Assay

Trypsin catalytic activity was determined using the chromogenic substrate, S-2222 (benzoyl-L-isoleucine-L-glutamic acid-[gamma-methyl ester]-L-arginine-p-nitroanilide), which was obtained from DiaPharma Group. The substrate was made up in deionized water followed by dilution in HBSA prior to the assay in which the final concentration was 250 micromolar (about 4-times Km). Purified (3X-crystallized; TRL3) bovine pancreatic trypsin was obtained from Worthington Biochemical

Corp. The enzyme was reconstituted in deionized water and diluted into HBSA prior to assay in which the final concentration was 0.5 nM.

Since modifications will be apparent to those of skill in this art, it is intended that this invention be limited only by the scope of the appended claims.